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A Defense of Bond Issues

An editorial article in the August issue of Roads and Streets answered some of the common arguments against borrowing money with which to build highways. One of our readers remains unconvinced and raises several questions that the editor attempted to answer in a letter to the reader. Believing that the answer may interest other readers, it is given as follows:

You quote Judge Gary as saying, "Refrain from anticipating your income in any respect." I think you will find that he was not referring to the borrowing of money for financing improvements for his own company (U. S. Steel Corp.) is mortgaged for more than half a billion dollars.

Every large public utility company and railway in America is heavily mortgaged. In fact, the bond issues average about half their total capitalization.

Money must be raised annually in large volumes with which to build utility and railway plants. About half is raised by the sale of bonds and half by the sale of preferred and common stocks. There is no essential difference between these three classes of securities other than their relative degree of risk. The bond is least risky, the common stock the most risky, and in between lies the preferred stock.

It seems to me that either you are wrong as to your views on the economics of bond issues or else the presidents of all our utility companies and railways are wrong.

If bond issues are desirable as a means of raising capital for public utilities and railways, then, by parity of reasoning, they are desirable as a means of raising money for needed public improvements.

Not a single state in America had a road system worthy of the name until heavy bond issues for road improvement were begun. The "pay as you go" theory simply did not work. Probably the opposition to the heavy taxation involved in a "pay as you go" plan accounts for its failure At any rate it has failed to produce adequate road improvement anywhere. When one plan fails, while another works, I cannot follow the theories of those who advocate the method that results in failure.

You ask whether America is not already too greatly in debt. And my reply is that it is not. We could not avoid our greatest debt, namely, that due to the war. Our other debts represent for the most part investments in the Panama Canal, school houses, post offices and other public buildings, roads and streets, water works and sewers and the like. And it can't be said that we have put too much capital into any class of public improvements. The fact is that we spend vastly greater sums annually on moving pictures and similar amusements.

You speak of "extravagance" as if it were something to be avoided. If by "extravagance" you mean individual spending for living expenses more than is earned, I agree with you; but if you mean spending for things other than necessities, I disagree with you. A cheap suit, a pair of brogans, a log cabin and three "squares" a day are all that most of our forefathers had, and all that we really need. Practically all the rest is spent for luxuries.

The average worker has earnings that give him five times the buying power that his great-great grandfather had. His great-great grandfather had all the necessities of life, so the descendant must be spending fully four-fifths of his income on luxuries, and is therefore very extravagant, in one sense of the term, and not at all so in another sense. The chances are that within the lifetime of persons now living, the earnings of the average worker will be threefold what they are today; and if so, one-fifteenth of the income will be spent for necessities and fourteen-fifteenths for luxuries. And I ask, why not? What are we living for? Merely to keep body and soul together?

You will understand, I hope, that I sympathize with every effort to reduce the waste of public money, and that I advocate only wise expenditures. Wasteful expenditure often occurs regardless of whether the money is raised by bonds or by taxes. But it seems to me that you identify bonding with wastefulness, and that that is an error.

H. P. Gillette

The Road to Profits

Hand labor has given way to the modern labor saving machine. Admittedly the modern paver has proven profitable, and a contractor would not think of planning a concrete paving operation without using one of these machines. Now comes a newer method of design that affords an opportunity for the contractor to make yet further use of this money-making equipment to his financial advantage.

The center joint has split the road into two roads. It increases the time needed, and the expense, to pave each mile since each strip must be paved, under most plans of procedure, independently of the other. But this method is not necessary. In fact, the very division of the highway into two or more strips presents a golden opportunity for further profits.

Why not use a separate paver for each strip and work the pavers one alongside the other? In effect, on a two-strip highway, this will make for two crews and plants working one with the other. Besides affording easier and better alinement of the center joint, it will double the savings that come from the use of the equipment, and will institute a spirit of competition between the crews that will result in a greater yardage per day.

1928 A.R.B.A. Convention and Road Show

A Few Pointers on the Place and Program Recently Announced by the Association

Cleveland was selected as the next location of the Convention and Road Show of the American Road Builders' Association because it was quite apparent that Cleveland came nearer fulfilling the requirements of this convention than any other city that was considered. There will be 45 per cent more space for exhibition purposes than was afforded in the Coliseum in Chicago. This means that the exhibitors are going to be able to not only show more of their products but will be supplied with sufficient room to more adequately display them.

Each year the Convention and Road Show of the American Road Builders' Association has grown to such an extent that the largest exhibition halls in the country are inadequate.

In looking around for better facilities for the Road Builders' Convention several places were considered. It finally narrowed down to Philadelphia, Atlantic City, Chicago and Cleveland. Philadelphia had a wonderful exhibition hall, which was constructed for the Sesquicentennial. However, this hall was not heated and no assurances could be obtained that it would be heated. Other buildings in Philadelphia were no improvement over Chicago. Atlantic City invited the convention to go there, but after sending a representative to the Chicago Road Show, frankly stated that they could not adequately take care of the Road Builders' convention until they completed their new building. This would not be completed, however, in time for the 1928 Road Show. Chicago had excellent hotel accommodations, but was somewhat limited on exhibition space. And so, after careful consideration, Cleveland was selected.

In order to allow as much space as possible for exhibition purposes and the display of newly developed equipment and material, the convention will be held in the assembly rooms of the Hollenden Hotel, which has been selected as official headquarters of the American Road Builders' Association. The Hollenden Hotel is located within one block of the Auditorium so the close proximity of the Convention and Road Show will assure good attendance to both events.

Cleveland has assured the Road Builders' Association that they will adequately provide hotel accommodations for everyone that attends the convention. Already a hotel committee has been organized and a well regulated method for securing hotel accommodations has been established.

The chairman of the hotel committee is Mr. Frank A. Peck, who will be ably assisted by Mr. A. J. Kennedy, vice-chairman. Twenty thousand hotel information blanks have already been sent out, setting forth the method of obtaining hotel accommodations.

In order to assure satisfactory accommodations for all attending the Convention and Road Show, the Cleveland hotels have pooled their rooms and these will be allotted through the hotel committee.

The Road Show will open at 9 a. m., Monday, January 9, and will be open on Tuesday and Thursday evenings—thus providing a longer time for visitors to inspect the exhibits. The second day of the Road Show and first day of the convention will be "Governors' Day" and invitations are being sent to governors of all states inviting them to be present at the convention. Wednesday will be "Pan-American Day," and although this was considered a huge success at last year's convention, already plans are under way to make this day much greater than formerly. Thursday will be "County Highway Officials' Day" and the engineers' and officials' sections of the convention will be devoted to the reports of this newly organized division.

On County Officials' Day a part of the program will contain a report by Mr. C. N. Connor of the Highway Research Board on "Low Cost Road Construction." This will be a very important report, especially as it affects the County Highway Officials' Division.

The Road Show will be held for five days and the convention will be held for three days. It will be divided, as in previous years, into two sections, one for the engineers and officials and the other for the contractors.

On Wednesday evening the Road Builders' banquet will be held in the Hollenden Hotel, and although the number present last year was approximately 1,600, the number this year will necessarily, on account of the hotel accommodations, be limited to 1,200.

The Road Show will be held in the Cleveland Public Auditorium and West Wing. These buildings have been constructed especially for convention purposes, and every facility for handling a convention can be found in these buildings.

The expense to the exhibitors this year will be reduced over last year, especially in the haulage of their equipment to the exhibition halls, and in other expenses. Exhibitors shipping full carloads can have the car spotted immediately adjacent to the Auditorium, which will save a great deal in the handling of their equipment. Requests from new exhibitors have been very great, and there is every evidence to show that this year there will be present a large number of new exhibitors, which in previous years it was impossible to provide for on account of the lack of space.

The Road Show this year will be open Tuesday and Thursday evenings. This will not only provide a means for the Cleveland people to visit the show, but will also provide a time for the engineers and officials who are busy at the convention to inspect the machinery at the show.

Cleveland is truly a convention city, and has every facility for handling large conventions so that everyone attending the Convention and Road Show of the American Road Builders' Association will find that the convention is conducted in a way whereby he can get the most out of his four or five days that he spends in that city.

Already contracts have been made and arrangements completed for the handling of the 350 carloads of equipment and material that will constitute the Road Show.

Every assurance has been given that the 25,000 people that will attend the convention will be properly housed.

The latest methods in construction maintenance and operation will be discussed at the convention, and the manufacturers will have on display their latest developments in equipment and materials.

The Road Builders' Banquet will be held on Wednesday, January 11, at the Hollenden Hotel, Cleveland. Inasmuch as the hotel facilities will accommodate only 1,200, reservations should be made as early as possible.

The Hotel Committee of the American Road Builders' Association has exclusive control of all rooms in best hotels in Cleveland, has arranged with the C. & B. Line to place in service its luxurious steamers, and will maintain a Hotel Bureau for purpose of making room assignments.

All requests for rooms should be addressed to A. J. Kennedy, Vice-Chairman Hotel Committee, American Road Builders' Association, 304 Chamber of Commerce Building, Cleveland.

The Hotel Bureau will open September 20. Applications may be filed prior to that date providing requirements are definitely known, but all such requests will be considered as bearing date of September 20. If members will plan to share rooms with fellow members or fellow representatives or employees, it will facilitate the assignment of rooms and secure a lower room rate per capita in hotels. Several of Cleveland's new and large hotels have many rooms which will comfortably care for two, three, or even four persons. The four-person rooms should prove particularly attractive to firms sending several representatives or employees and desiring to effect a saving in room costs. Practically all rooms available for more than three-person occupancy will contain individual beds.

Successful Macadam Bridge Decks

Los Angeles County Road Department Paving Wooden Bridges With Bituminous Macadam

By W. W. SHELBY
Assistant District Engineer

Los Angeles County has many wooden bridges, the decks of which are covered with various kinds of pavements. Our experience has been that generally speaking, the "hot mix" type will crack, due to the vibration caused by traffic, the degree of cracking varying with the length of span, other things being equal. This has led to the practice of using bituminous macadam pavements, from which we invariably get satisfactory results.

Fig. 2—Applying Oil on Base Rock

Method of Construction.—The pavement here described is on a bridge 697 feet long by 25 feet wide inside of the spreaders and contains eleven Howe trusses. The decking is constructed of 2 by 6 inch plank spiked on edge and is known as a laminated deck. This flooring is creosoted and not surfaced. An unevenness resuits due to the difference in the width of the lumber, the maximum difference being as much as one-half inch, thus giving a decided tendency to prevent movement of the pavement on the deck. A 2 by 12-inch spreader is bolted along the sides of the bridge to furnish a shoulder.

Fig. 1—Smoothing Base Rock

After sweeping the deck, 90 per cent asphaltic road oil is applied hot by a pressure distributor at the rate of ⅜ gallon per square yard. On bridges where the decking is flat and not laminated, less oil is used, usually ¼ gallon. On this oil No. 1 crushed rock (3½-inch to 1½-inch) is spread by dump trucks, the trucks driving over the oil. The spread is evened up and crowned by hand so that it is about 2 inches thick at the spreader and about 4 inches at the center. The 2-inch thickness is obtained by raking out the larger rock along the edges. It can also be obtained by using smaller rock on the outer quarters. Great care is given to the amount of base rock used as well as the shaping of it, for we consider that if the proper section is not secured at this stage it will be difficult, if not impossible, to successfully obtain it later. If the rock contains much round material it is rejected. Nevertheless we generally resort to some cleaning by hand as the locking action on a wooden bridge is practically nil, and simply impossible in the presence of round aggregate. An eight-ton tandem roller now irons out the spread so that any irregularities are apparent. Low areas are brought to grade by the addition of the same size rock.

Rolling is now continued until the rock is firm, bearing in mind that the danger point is reached when the material crushes too much. The best results are obtained by a rock that crushes slightly under the roller. In this particular case twice over proved to be sufficient rolling for the first course. The voids are now partially filled by applying No. 3 crushed rock (¾ to ¼-inch) at the rate of about 1 pound per square foot. If too much filler is used, rolling will force it to the bottom. The writer recalls a recent case where the base rock would not lock, so more

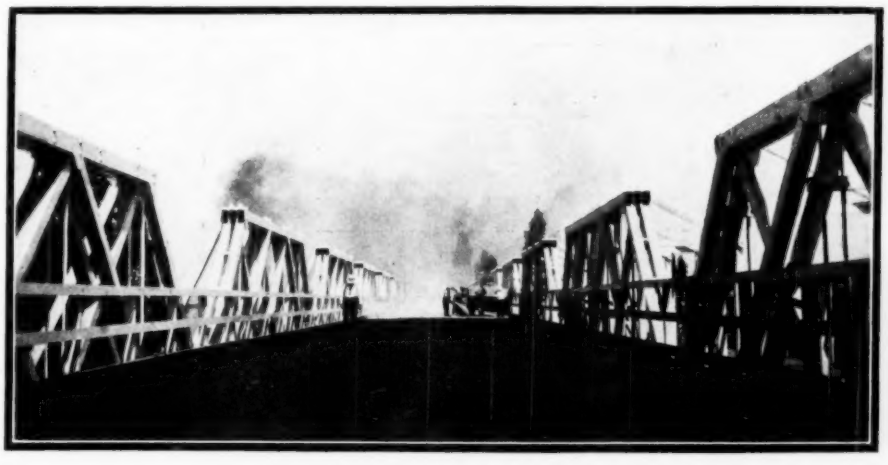


Fig. 3—Spreading No. 4 Rock on Oil

filler was added and the roller was generously used, with the usual result that all the fines went to the bottom and the entire mass had to be removed. The tandem, by one rolling, sets the filler. Oil is applied to this at the rate of ¾ gallon per square yard. As the bottom course varied in thickness from 2 to 4 inches, ⅝ gallon was applied to the thinner portion and ⅞ to the thicker. This oil is covered with a layer of No. 3 crushed rock. It is spread by hand from a maintenance truck and broomed to the proper section. As the quantity used was only about 9 pounds per square foot, no attempt was made to spread by dump trucks. It is rolled by the tandem until well set and firm, rolling being stopped if undue movement of the pavement becomes apparent. Oil at the rate of ½ gallon per square yard follows, this being covered with No. 4 crushed rock (¼-inch to 0). Two or three rollings with the tandem will usually prove sufficient to leave the deck in the proper condition. In some cases a three-wheel roller might be used on the finish, but not at any other stage of the work.

The various operations have been described with much detail, as it is believed the successful laying of this class of pavement on wooden bridges is a difficult task. The principal difference between this decking and a bituminous pavement on a good sub-grade is that satisfactory locking cannot be obtained, but its imitation is attempted by the judicial use of the proper quantity and proper quality of oil. All oil used contained approximately 90 per cent of bitumen.

The weight of a uniform section of well rolled asphaltic concrete pavement three inches thick would be around thirty-seven or thirty-eight pounds per square foot. Hence it appears that this pavement, with a larger percentage of voids, exceeds the average thickness of three inches.

The field work was done by Paved Way Foreman Joe Burkhard, under the supervision of Mr. A. W. Butler, district engineer of maintenance.

Fig. 4—Rolling the Finished Pavement

Costs

Material	Quantity	Total Cost	Cost Sq. Ft.	% Total
Oil—90% bitumen	3,250 gal.	$178.00	.....	.....
No. 1 crushed rock	245 tons	563.50	.....	.....
No. 3 crushed rock	80.5 tons	161.00	.....	.....
No. 4 crushed rock	33 tons	66.00	.....	.....
		$968.50	$0.056	70.9
Labor and Equipment				
Cleaning bridge	.....	$ 17.25	.....	.....
Spreading No. 1 rock	.....	86.15	.....	.....
Spotting No. 1 rock	.....	17.21	.....	.....
Filling voids	.....	23.73	.....	.....
Hauling and spreading No. 3 rock	.....	68.92	.....	.....
Hauling and spreading No. 4 rock	.....	68.92	.....	.....
Rolling, depreciation, etc.	.....	50.10	.....	.....
Maintenance truck	.....	72.00	.....	.....
		$404.28	$0.023	29.1
Totals	.....	.....	$0.079	100.00

Weight of Materials

Materials	Lbs. Per Sq. Ft.	Pct. of Total
No. 1 crushed rock	28.0	68.3
No. 3 crushed rock	9.2	22.4
No. 4 crushed rock	3.8	9.3
	41.0	100.0
Oil	1.4	
Total	42.4	

Pike's Peak Highway to Belong to U. S. in 1935

Public ownership of a motor highway to the summit of Pike's Peak in Colorado, not later than December, 1935, is guaranteed by the action of Secretary Jardine who has accepted the offer of the Pike's Peak Auto Highway Co. to convey to the United States its present highway to the summit of the famous mountain, together with 500 acres of privately owned land and all structures appurtenant to the operation of the road, subject to the reservation by the company of the right of use without competition and at prevailing toll rates until the close of the season of 1935. The offer was accepted in preference to the proposal of W. D. Corley to construct a second toll road to the summit of the Peak, on the opposite side of the mountain, with the understanding that at the end of six years the new road together with the present Corley Mountain Highway from Colorado Springs to Cripple Creek would become public property without cost.

In reaching his decision, Secretary Jardine expressed the belief that a single road to the Peak would be sufficient to accommodate the public; that a second road would cause needless disturbance of natural conditions and involve heavy expenditures for which no economic justification existed; that the division of probable business between two competing roads might make it impossible to maintain or operate either according to proper standards; and that the construction of the proposed new road through the watershed from which the city of Colorado Springs secures its municipal water supply might be detrimental to public health. An additional consideration is the Secretary's belief that all toll roads in National Forests should be made free public highways and turned over to the states for control and maintenance as rapidly as practicable. It is probable that the State of Colorado will be willing to assume the maintenance of one highway to the Peak, but quite improbable that it would undertake the maintenance of two roads serving a single objective point and class of users.

The Pike's Peak Auto Highway Co. secured a permit to construct and operate a motor toll road to the top of Pike's Peak, from the Department of Agriculture, in 1915. The permit provides that in 1940, or at five-year intervals thereafter, the public might assume ownership of the road by paying the cost of its construction. The Auto Highway Co. has now agreed to meet the demand for a public road by conveying to the United States its rights and property under the permit, plus its appurtenant lands and structures, if guaranteed a continued right of use sufficient to permit amortization of its investment.

Truck and Railroad Tonnage

Extract from Report on Survey of Transportation on Ohio State Highway System

In order to determine what proportion of the total tonnage of commodities moving between cities is hauled by motor truck, and also to develop the factors influencing the choice of motor truck or railroad, an analysis was made of the net tonnage hauled between Columbus and 34 Ohio cities by motor truck and rail lines.

The cities selected are located from 7 to 134 highway miles from Columbus and were chosen to permit an analysis of the effect of length of haul upon the proportions of tonnage transferred by motor truck and railroad, respectively. Hillsboro and Johnstown, both having indirect rail connections with Columbus, were selected to determine the effect of indirect rail connections upon motor truck transportation. Commercial Point, Dublin, Reynoldsburg and Rome were selected to ascertain the amount of tonnage hauled by truck between points having no railroad facilities.

Motor truck net tonnage and railroad carload and less-than-carload tonnage data for an average month of 1925 were taken as the basis for this comparison, as shown in Fig. 1, the size of the circles for each city indicating the total net tonnage transported.

It is apparent that distance is an important factor in the amount of tonnage hauled by motor truck. Between Columbus and Akron, Cincinnati and Toledo, distances of over 100 miles, a very small part of the total tonnage is hauled by truck, while between Columbus and Grove City and between Columbus and Alton, distances of 8 and 9 miles, respectively, almost all of the tonnage is transported by motor truck.

Table I—Proportion of Motor Truck and Railroad Net Tonnage According to Length of Haul for Average Month, 1925*

Length of haul (highway miles)	Motor truck Tons	Motor truck Per cent	Rail (carload) Tons	Rail (carload) Per cent	Rail (less than carload) Tons	Rail (less than carload) Per cent	Total Tons	Total Per cent
Less than 20	6,091	84.5	1,112	15.4	10	0.1	7,213	100.0
20-39	5,973	54.7	4,803	44.0	145	1.3	10,921	100.0
40-59	2,299	32.0	4,484	62.4	404	5.6	7,187	100.0
60-99	980	24.2	2,409	59.4	663	16.4	4,052	100.0
100 and over	157	2.3	5,280	77.4	1,383	20.3	6,820	100.0

*Based upon tonnage between Columbus and 30 cities having rail connections.

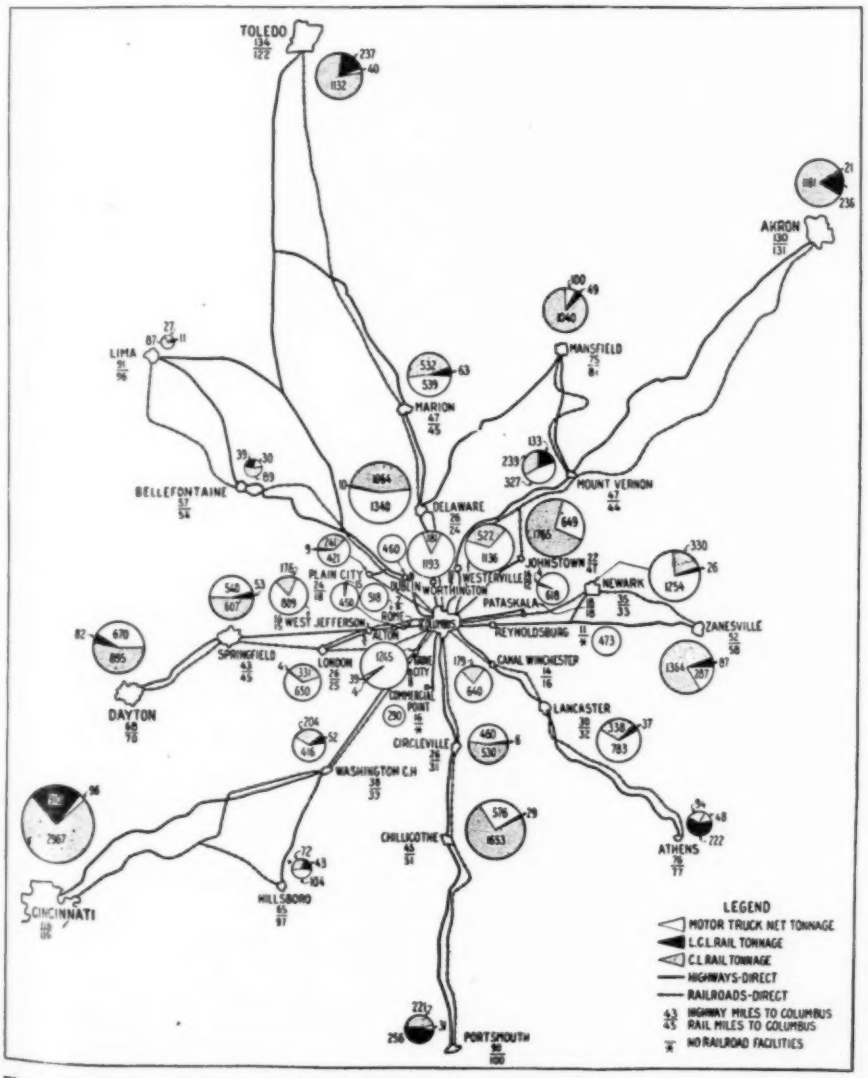


Fig. 1—Comparison of Motor Truck and Railroad Net Tonnage Between Columbus and Selected Ohio Cities

Length of Haul and Tonnage.—Table I presents a summary of the relation between motor truck and rail tonnage according to length of haul.

Although other factors besides length of haul influence the proportions of total tonnage hauled by motor truck and rail lines, respectively, and although the number of cities in each zone of haul (Table I) is not large, there is clearly indicated the tendency for the proportion of motor truck tonnage to decrease with increase in distance. For hauls of less than 20 miles, 84.5 per cent of the total tonnage is transported by motor truck; between 20 and 39 miles, motor truck tonnage is 54.7 per cent of total tonnage; and for the longer hauls, motor truck tonnage is 32, 24.2 and 2.3 per cent, respectively. As the percentage of motor truck tonnage decreases with increase in distance both rail, carload and less-than-carload tonnage increase. No appreciable amount of less-than-carload tonnage is noted under 40 miles. Between 40 and 59 miles the less-than-carload tonnage is 5.6 per cent of the total and this percentage increases to 20.3 for distances of 100 miles or more.

Controlling Factors.—Among other factors controlling the proportion of total tonnage hauled by truck are the type of commodities and rail facilities. An illustration of the former is indicated in the movement between Columbus and Johnstown. Although Johnstown is only 22 miles from Columbus by highway and 41 miles by railroad, 73.1 per cent of the tonnage is hauled by rail, practically all of which moves in carload lots. This high percentage of rail tonnage, considering the comparatively short highway mileage and the longer rail connection, is due to the type of commodity transported, 95.7 per cent of the total tonnage being gravel, sand and stone. These commodities can not be economically hauled by motor truck for this distance, as is indicated by the fact that the average length of haul for trucks hauling gravel, sand and stone in Ohio is only 10 miles.

The influence of indirect rail connection upon the proportion of motor truck and rail tonnage is shown between Columbus and Hillsboro, a distance of 65 miles by highway and 97 miles by railroad. Between these points 47.5 per cent of the total tonnage is carried by motor truck. Reference to Table I shows that, under normal conditions, between 40 and 59 miles, only 32 per

cent of the total tonnage is carried by motor truck, and that between 60 and 99 miles the corresponding figure is 24.2 per cent. It is evident that the relatively high percentage of motor truck tonnage between Columbus and Hillsboro is due, in large part at least, to the fact that the distance by highway is 32 miles shorter than the distance by railroad.

Sixth Annual Asphalt Paving Conference at Atlanta

The 6th Annual Asphalt Paving Conference will be held at the Atlanta-Biltmore Hotel, Atlanta, Ga., under the auspices of The Asphalt Association and The Association of Asphalt Paving Technologists, during the week of Nov. 28th, and will bring together a distinguished personnel of engineers, officials, asphalt research specialists, contratcors and manufacturers in a very practical and analytical meeting, according to advance information given out by The Asphalt Association, New York, of which J. S. Helm is president.

Thomas H. MacDonald, chief of United States Bureau of Public Roads, is listed as one of the outstanding speakers. Col. Woolsey Finnell, director of highways of Alabama, is chairman of the Engineering Committee, and his associates on the committee constitute an impressive list of the foremost state, city, county and research engineers throughout the United States, including the following: J. T. Bullen, parish engineer, Caddo Parish, Shreveport, La.; Harwood Beebe, consulting engineer, Spartanburg, S. C.; R. Keith Compton, director of public work, Richmond, Va.; J. H. Dingle, city engineer, Charleston, S. C.; Jay Downer, chief engineer of Westchester County Park Commission, Bronxville, N. Y.; G. F. Fisk, first assistant city engineer, Buffalo, N. Y.; W. B. Fowler, city engineer, Memphis, Tenn.; Capt. James M. Garrett, city engineer, Montgomery, Ala.; W. S. Hawkins, Harrison County engineer, Gulfport, Miss.; G. H. Henderson, chief engineer, Rhode Island State Board of Public Works, Providence, R. I.; J. B. Hittell, chief engineer, Board of Local Improvements, Chicago, Ill.; W. W. Horner, chief engineer, sewers and streets, St. Louis, Mo.; Col. J. M. Johnson, consulting engineer, Marion, S. C.; J. N. Mackall, chairman and chief engineer of State Road Commission, Baltimore, Md.; W. R. Neel, state highway engineer, East Point, Ga.; W. C. Olsen, consulting engineer, Raleigh, N. C.; P. C. Painter, city manager, Greensboro, N. C.; W. O'D. Rockwell, city engineer, Savannah, Ga.; H. L. Shaner, commissioner of public works, Winston-Salem, N. C.; H. B. Smith, Burlington County engineer, Mt. Holly, N. J.; R. M. Smith, deputy minister of highways, Toronto, Ont., Canada; Bryson Vallas, city engineer, New Orleans, La.

Francis P. Smith, consulting engineer of New York City, is chairman of the Research Committee. Associated with him are T. R. Agg, professor of highway engineering, Iowa State College, Ames, Iowa; A. R. Ebberts, engineer of tests, Allegheny county, Pittsburgh, Pa.; W. J. Emmons, research specialist, United States Bureau of Public Roads, Washington, D. C.; Roy M. Green, manager of Western Laboratories, Inc., Lincoln, Neb.; H. L. Howe, Jr., director, Municipal Testing Laboratory, Rochester, N. Y.; Prevost Hubbard, chemical engineer, The Asphalt Association, New York; L. M. Law, chief chemist, New Orleans Refining Co., New Orleans, La.; C. A. Mullen, consulting engineer, Montreal, Canada; Hugh W. Skidmore, president, Chicago Paving Laboratory, Chicago, Ill.; C. H. Underwood, city chemist, Indianapolis, Ind.

L. B. West, president of the West Construction Company, Chattanooga, Tenn., is chairman of the Contractors' Committee, consisting of B. N. Belcher, president, Belcher Asphalt Pacing Co., Inc., Miami, Fla.; I. N. Bransfield, Chicago, Ill.; E. T. Davis, Standard Paving Co., Toronto, Ont., Canada; W. S. Ely, president, Ely Construction Co., Augusta, Ga.; Sam E. Finley, Atlanta, Ga.; Wm. P. McDonald, president, Wm. P. McDonald Construction Co., Flushing, N. Y.; B. S. Russel, secretary, Cuyahoga Asphalt and Paving Co., Cleveland, Ohio; W. R. Smith, president, Lane Construction Company, Meriden, Conn.; R. B. Tyler, president, R. B. Tyler Co., Inc., Louisville, Ky.; Joe L. Blythe, Blythe Brothers Co., Charlotte, N. C.; J. H. Cranford, president and treasurer, The Cranford Co., Washington, D. C.

W. A. Hansell, Jr., chief of the department of construction, Atlanta, Ga., is chairman of the Local Committee. That the social aspect of the convention is to have equally distinguished management is indicated by the fact that Bobby Jones, greatest golfer of all time, will be active in the arrangements for the Golf Tournament, and will play an exhibition match with Watts Gunn, almost equally famous.

A survey of the equipment field in highway and street work will be presented by Chas. M. Upham, director of highway research of the National Research Council and business manager of the American Road Builders' Association. A survey of the surface treatment field will be presented by C. N. Conner, chairman of Low Cost Improved Roads Committee of the Highway Research Board. The technical research program at the session presided over by Hugh W. Skidmore, president, Chicago Paving Laboratory, Chicago, Ill., will include papers by A. R. Ebberts, engineer of tests, Allegheny County, Pa.; A. W. Dow, chemical engineer, New York; H. L. Howe, Jr., director of Municipal Testing Laboratory, Rochester, N. Y.; Francis P. Smith, consulting engineer, New York; Prevost Hubbard, consulting engineer of The Asphalt Association, New York; Victor Nicholson, engineering chemist, department of Public Works, Chicago, Ill., and others. State highway progress will be presented by the heads of state highway departments, including Ben M. Sawyer, chief highway commissioner of South Carolina; Col. Woolsey Finnell, director of highways of Alabama; C. N. Bass, state highway commissioner of Tennessee. Successful black base construction over a long period of years in Savannah, Georgia, will be described by City Engineer W. O'D. Rockwell, of Savannah, Ga. Relative advantages of smooth and rough texture asphalt surfaces will be discussed by Arthur H. Blanchard, consulting engineer, Toledo, Ohio. The economic management on a county highway system will be described by W. S. Hawkins, county engineer, Gulfport, Miss. Maintenance requirements and service records and what they have developed will be the subject presented by G. F. Fisk, first assistant city engineer, Buffalo, N. Y.

Big business is taking very keen note of the fact that the highway industry has reached the select billion dollar group. The producers and manufacturers represented at the conference will include the Standard Oil Company of New Jersey, the Standard Oil Company of Indiana, the Mexican Petroleum Corporation, the Midwest Refining Company, Imperial Oil, Ltd., of Canada, the New Orleans Refining Company and other big producers. The Asphalt Association, J. S. Helm, president, headquarters in New York City is active in the arrangements for the conference.

County commissioners of Fulton County, Georgia, of which Atlanta is the county seat, are arranging to provide a very unique entertainment and demonstration in the form of an old fashioned barbecue at the county convict camp, with an exhibition bloodhound chase and capture of an escaping convict. Numerous social features will be interspersed through the week's program.

Effect of Salts in Mixing Water on Strength of Mortar Studied

The bureau of engineering research of the University of Texas is now studying the results of a series of tests to determine the effect of various salts in mixing water on the strength of cement mortar. These tests have been made over a period of three years an a report is to be made soon. The bureau has recently moved into new and more commodious quarters and an enlarged program of research work is being planned for the future, according to F. E. Giesecke, director of the bureau.

"Turn Over" Method of Applying Asphaltic Oil

Report of Investigation of Method Developed and Practiced by California Highway Department Given in July New Mexico Highway Journal

By E. B. BAIL
Assistant Engineer, New Mexico State Highway Department

The period from June 2 to June 8 was employed by the writer in witnessing the operations prosecuted by the California Highway Department in applying road oil to the gravel surfaced highways by the so-called "turnover" process in the vicinity of Barstow, Calif.; in the observation of surfaces finished by this method and various forms and types of asphaltic construction in Los Angeles, Riverside, Orange and San Bernardino Counties, and in consultation with the officials of the oil companies in regard to probable costs based on possible New Mexico requirements.

The Method.—Essentially the present California practice consists in applying 1½ gal. of 60-70 per cent asphaltic oil to a gravel or crushed rock surface and then thoroughly mixing this oil with the surfacing to form an oil cake about 3 in. thick.

Climatic Conditions.—Barstow, Calif., at which point this work was being done, lies at an elevation of approximately 2,100 ft. The surrounding country is desert. The rainfall is about that of the most arid sections of New Mexico. High winds prevail during the spring months.

The road treated by the "turnover" method was a Federal Aid Project surfaced with crushed gravel 6 in. thick, 18 ft. wide. It was constructed in the early part of 1926.

Grading Analysis.—Screen analyses were made of material from several pits. The analysis shown below is of material taken from the pit finally used. It represents that part of the sample passing a ½-in. hole.

	Per Cent
Wash	17.9
200 mesh	20.8
100 mesh	27.4
80 mesh	30.8
50 mesh	37.3
40 mesh	43.4
30 mesh	50.5
20 mesh	65.1
10 mesh	85.3
¼ in.	98.0
½ in.	100.0

Remarks, (Material Engineer): "Good binder material. 4 to 6 yd. per station thoroughly mixed with top course should give excellent results."

The writer wishes to state at this point that he does not consider the above analysis typical of the material finally placed on the road. He would say that the surfacing as placed runs much coarser because of the fact that the contractor eliminated a large percentage of fines. However, it seemed to be the opinion of all connected with the work that the nearer the surfacing approached the above grading the better the results with oil.

Details of the Work.—The various operations may be listed as follows:

(1) Scarifying to depth of 3 in.
(2) Disc-harrowing to level up for oil.
(3) First application of ½ gal. oil per square yard.
(4) Disc-harrowing in the oil.
(5) 2nd application of ½ gal. oil per square yard.
(6) Disc-harrowing 2nd application.
(7) 3rd application of ½ gal. oil per square yard.
(8) Final disc-harrowing.
(9) Mixing with road grader.
(10) "Laying-down" ready for traffic.

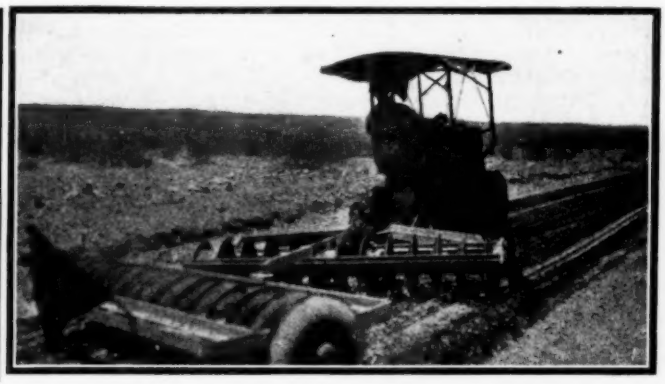
Scarifying.—This is done by two 1-man patrol graders with scarifier attachment. These machines are Spears-Wells graders powered with McCormick-Deering engines.

The operation of the scarifier can be closely controlled and this control is vital in securing a uniform depth. The object of the close control of the scarifier is to avoid breaking through the surfacing into the subgrade, though, due to lack of uniformity in the thickness of the gravel, the scarifier does sometimes break through. Scarifying of this sort is very slow and very hard on the scarifier teeth. A blacksmith and helper are kept busy sharpening even with a supply of some 300 teeth.

The first trip of the scarifier is made along the edge of the surfacing and often one tooth only can be used on this first trip; occasionally it is possible to use three teeth. Scarifying proceeds from the outside toward the center. After the first cut has been made clear across the roadway, more teeth are put in until, on the final cut, a machine can use the full set. These scarifiers have a marked pulverizing action due partly to their being set close together. Eight-tenths of a mile is considered a good performance for scarifier teeth on this class of work.

Disc-Harrowing.—Immediately following the complete scarification of a section it is disc-harrowed to level up the loosened surfacing preparatory to oiling. This harrow consists of a double set of discs set at an angle with each other, so that one set will throw the material in the opposite direction to the action of the first set. In operation the two sets form a V. The mixing action of this apparatus is very pronounced with a comparatively small expenditure of power, as it is easily pulled by a 2-ton Caterpillar tractor. The harrow used is known as the Towner 9-ft. Offset disc-harrow. The discs are 22 in. in diameter and of 7

Operation 1: Final Scarifying; Road Ready for Disc-Harrow to Level Up Before Oiling



Operations 2, 4, 6, 8: Disc-Harrow, Drawn by 2-Ton Tractor, Harrowing After Oiling

gauge metal. Each harrow has 14 discs.

Oiling.—Oiling is done with a pressure distributor mounted on a heavy duty truck. The distributing mechanism is operated from a power take-off which is furnished with the truck on order, since it is not part of the regular equipment. As it is extremely important that an even flow be maintained, only skilled operators are allowed to handle this work. The governor of the truck is so adjusted that when the application is being made at the proper rate, the truck is working at the limit of its governed speed; or, as the operator put it, "working against the governor." The two men operating the distributor are rated by the Gilmore Oil Co. as their best men. That they have developed exceptional skill is evidenced by the fact that on a section of 17 miles with a theoretical application of 1½ gal. per square yard, a check showed the actual rate to have been 1.3 gal. per square yard.

Operations 3, 5, 7: Applying the Oil; ½ Gal. Per Square Yard Applied Each Trip. Oil Applied Over Half of Roadway, Traffic Using the Other Half. Three Trips Required for Total Application

In advance of the oiling, stakes are set a distance of 10 ft. from center of roadway to guide the driver of the distributor so that the outside nozzle will throw to the line marked by the stakes.

The rate of application was intended to be 1½ gal. per square yard over a width of 20 ft. For this width there are 11,733 sq. yd. per mile, requiring 17,600 gal. per mile. The distributor tanks hold 1,100 gal. To cut down the number of turns, which would have been excessive if the full amount of 1½ gal. was put on at one application, it was decided to apply a third of the amount at each application. This works out to a trip-length of approximately 0.4 mile for each tankfull, and this was the rule by which the tank operators gauged the application.

Disc-Harrowing First Oil Application.—As soon as the distributor starts over the section to be treated, the disc-harrow pulls in behind it and begins mixing the oiled surfacing. It follows the distributor to the end of the freshly-treated section, and then goes back and forth over the section until the tank returns. This is one operation that cannot be overdone. A spring-tooth was also drawn behind the discs but it is believed this implement could be dispensed with.

Final oiling and Harrowing.—The second and third oil applications and the subsequent disc-harrowing are carried on as described for the first application.

Mixing With Road Graders.—Immediately following the final application of oil and its attendant harrowing, the mixing proper begins.

For this purpose, two patrol-graders, of the one-man type, follow the discs. The oiled material is thrown into the center from both sides forming a long windrow. Then this windrow is gradually worked to one side until it forms another windrow. This shifting is kept up until the material assumes a dark chestnut color. In this operation, as many patrol-graders are used as may be available; if the graders with scarifier attachment are not busy elsewhere, they are put at the mixing.

At this point it should be stated that the faster the blade moves the better the mixing action because of the better roll given the mix.

"Laying Down" the Roll.—When the mix has developed the proper color, the small one-man graders are taken off and a 10-ton blade drawn by a "60" Caterpillar tractor spreads the finished material uniformly across the road. The blademan selected for this work is rated as the best the department has and no one else is allowed to handle this final operation.

Final Touches.—When the mix is "laid down" the road is opened to traffic. During the work between Barstow and Daggett, traffic used the road at all times, merely switching from one side to the other as the mixing proceeded.

Immediately after the mix has been "laid down," a 7-ft. grader drawn by a small tractor, (2-ton Caterpillar or its equivalent), begins working the road behind the traffic for the purpose of keeping the surface smooth during compaction. When traffic first moves over the finished roadway a Ford car will sink into the surface as much as an inch. Within 3 hours a Ford makes no impression and in 3 days a 22,000 lb. load will leave only faint marks which are quickly ironed out by following traffic. The blade is kept steadily working until no further material can be moved, this stage usually being reached about the third day. For this work it is desirable that a rubber-tired tractor be used to avoid cutting up the surface. If such a machine is not available, a tractor equipped with street tracks, that is, one with a track composed of flat shoes, will be satisfactory, but in no case should lug wheels of a Caterpillar with grousers or lug shoes be used on the finishing work.

Organization.—The force doing this work has been built up over a period of a year. As it stands at present, it represents the California Department's latest views; it has increased greatly in efficiency as evidenced by a comparison of the latest costs per mile with costs of last year's work. The force is doing now for $1,025 per mile the same work which cost up to $1,600 per mile last year. The greater part of the reduction in costs has been brought about by a change in methods and machines, the number of men required remaining about the same. It is significant that practically the same crew has been retained throughout the work. This, it is believed, has been a large factor in securing the present excellent class of work.

Equipment.—The equipment consists of the following:

2—One-man patrol graders with scarifier attachments.
3—One-man patrol graders with blades only.
1—Rubber-tired McCormick-Deering tractor.
1—7-ft. grader (used with above tractor for finishing behind traffic).
1—"60" Best Caterpillar pulling 10-ft. blade for "laying down."
1—10-ft. Adams Grader (used with the "60").
1—2-ton Caterpillar pulling disc-harrow.

Operation 9: Mixing Treated Surfacing With 1-Man Patrol Grader. The Mix Has Been Thrown to Center From Left Side and Is Now Being Brought in From the Other Side. This Operation Gives the Process Its Name, "Turnover." The Mixing Action Is Very Pronounced. It Is Considered Desirable to Take a Light "Roll" and Move the Machine as Rapidly as Possible Because of the Better Mixing Action at Higher Speed. This Operation Is Continued Until the "Mix" Is a Uniform Dark Chestnut Color. It Is Then Ready for the "Laying Down"

1—Graham 1½-ton truck for servicing.
2—Ford roadsters with pick-up bodies, (1 for foreman, 1 for timekeeper).
1—Offset disc-harrow.
1—Spring-tooth harrow.
1—Set blacksmith equipment.

Crew.—The crew is as follows:

1—Foreman.
1—Timekeeper.
1—Truck driver.
1—Blademan operating 10-ft. blade.
6—Blademen operating 7-ft. blades.
1—"60" Runner.
2—2-ton Runners.
1—Blacksmith.
1—Blacksmith helper.
3—Laborers.

The above crew is the regular state force. The Gilmore Oil Co. furnishes the distributing equipment, pays the operators, handles all demurrage and heating of oil, for a contract price per gallon of oil applied to the road. This price varies with the length of haul; hauling from Daggett west, the price was 0.0377 ct. per gallon.

Costs.—The cost per mile has been steadily decreased, but had about reached bedrock on June 2nd, when it was given as $1,025 per mile, with oil at 0.377 ct. per gallon.

The cost of the separate operations as scarifying, mixing, laying-down, are not available except indirectly. The cost of applying oil may be approximated by using the average actual application of 1.3 gal. per square yard. For a 20-ft. width, the cost is: 11733x 1.3x0.0377, say $575 per mile. This leaves $450 for other operations.

This $450 is roughly used as follows:

	Per Mile
Labor	$186.00
Equipment rental	120.00
Gas, oil and supplies	144.00

In this connection it might be of interest to note the equipment charges against the machines used.

Equipment Rentals.—Charges per day against:

"60" Caterpillar	$16.00
Spears-Wells Patrol-grader with scarifier	7.00
Spears-Wells Patrol-grader with blades only	4.70
Gallon Patrol-grader with blades only	5.50
McCormick-Deering tractor	3.75
1½-ton Graham truck	5.00
Ford roadster (pick-up body)	2.00
10-ft. Adams grader	1.50

Miscellaneous Charges.—Charges which are difficult to allocate to any particular item of the work constitute a surprisingly large amount; for instance on 23.6 miles of the "turnover" work these charges totaled $3,043; this included gas, oil, heavy hardware, disc-harrows, spring-tooth harrows and grader blades. The item for grader blades alone was $700.

The Oil.—The oil used for the "turnover" process is what is termed "Medium Road Oil"; it is of approximately 14 gravity and is delivered to the work in practically the condition in which it comes from the well, in fact the only treatment to which it has been subjected is an alectrolytic process for removal of water. It is generally referred to by the engineers as 65 per cent oil, meaning its content of 80 penetration asphalt.

The Finished Road—Riding Qualities.—Vialog tests on the finished road demonstrate it to be smoother than any other type of road on the California Highway System and this includes concrete, asphaltic concrete, and bituminous macadam.

Operation 10: "Laying Down" the Mixed Material

Operation 10: The Operation Completed; the Mixed Material "Laid Down" Ready for Traffic

Resistance to Wear and Behavior Under Sustained Traffic.—The writer rode over sections of this type of road which have been in service for 9 months under an average traffic of 600 cars per day (passenger and light trucks). No wear was apparent; no rutting had taken place.

Construction Defects and Remedies.—Here and there over the completed 26 miles, one would observe streaks of very light-colored material showing a raveling action. This indicates a too lean mix. The remedy, when the condition is present only in isolated spots, is to dig out the lean material and replace it with a mix of proper consistency taken from stock piles.

Along other sections a very dark surface appears along the lane of heaviest traffic. This indicates a mix too rich in oil—too "fat" is the usual term. There are more sections of this type than of the "lean" type, indicating that the first construction tended toward a rich mix. These sections usually occur in fairly long stretches. The remedy is to scarify and remix. For this purpose they use a one-man machine with scarifier attachment operated by one of their most experienced men. This operator will scarify, remix and "lay down" about 1,000 ft. per day. The process is practically identical with new construction. It is a job calling for much experience, including a fine discrimination for color, because of the fact that considerably less than ½ in. of additional dry material is all that is necessary to bring the mix to the proper consistency. As the color and consistency of the final mix cannot very well be determined until the whole mass has been laid down, it is evident that an inexperienced man could easily make this operation a very costly one.

Should error in judgment have produced too lean a mix, the only remedy is to bring up the oil distributor and apply ⅛ gal. per square yard. This application is then covered by shoulder material. The department now inclines toward a mix so lean that it will ravel. It is then sealed with ⅛ gal. per square yard following with a cover of shoulder material. The amount of oil will not be materially reduced but a thicker cake will be formed and "bleeding" will be eliminated.

Maintenance.—Maintenance to date has consisted only in remedying construction defects as noted above. On those sections where a uniformly dark chestnut color was obtained at the start there has been no charge for maintenance.

Change in Construction Practice.—It is of interest to note that construction practice has changed somewhat even in the short time of a month. Compare practice as outlined April 28, 1927, with the methods the writer found in effect June 2:

April 28: "This loosened surfacing is thoroughly bladed from one side of the road to the other and back again. This operation uniformly mixes the gravel with the filler and also produces a surface without irregularities."

June 2: "The writer finds that this preliminary blading has been abandoned for the reason that the same result is gotten a little later by the same method after the oil has been applied. Result:

The Finished Road—1926 Work

a lowering of costs without lowering quality of finished product."

April 28: "Clean sand required as filler for the seal coat. Brought in by truck and applied by hand. Expensive."

June 2: "Shoulder material found to be a satisfactory filler; is spread by graders. Another cut in costs."

These changes in practice, all tending to lower costs, have been going on for a year. It speaks much for the open-mindedness and willingness to learn on the part of the men engaged in the work.

As the experiment stands now California feels that it is a success, but it is not claimed to have reached the ultimate, either in methods or costs.

Two More Manufacturers Merge

Directors of The Brown Hoisting Machinery Company, Cleveland, and Industrial Works, Bay City, Michigan, have approved plans for a merger of the two companies, to be made effective when ratified by their respective stockholders at meetings which will be held in the near future. Discussions leading to this merger have been proceeding for many months, and this announcement is the culmination of intensive work on the part of the late Mr. E. B. Perry, formerly President of Industrial Works; Mr. Alexander C. Brown, President of The Brown Hoisting Machinery Company, and other executives of the two companies. The businesses to be joined both occupy important positions in the materials handling industry. The physical properties, the earnings, the standards of design and workmanship, and the personnel of both companies are very similar. A well-known firm of public accountants has made the following statement: "It has seldom been our experience to come into contact with a situation in which the conditions were as appropriate for a consolidation or merger as in this instance."

The object of consolidation is to render better service to users of material handling equipment by means of eliminating duplication or overlapping of product where it exists, by effecting economies in manufacturing and by concentrating in each plant that portion of the work which can be produced to the best advantage.

The Brown Hoisting Machinery Company was founded in 1880 by Alexander E. Brown. This company designs and manufactures hoisting and conveying appliances and heavy handling machinery of all descriptions, including locomotive cranes, grab buckets, combination shovels and cranes, ore unloaders, bridge cranes, gantry and portal cranes, trolleys, hand traveling cranes, and conveyor equipment. The principal plant of the company occupies nine and one-half acres, fronting on St. Clair Avenue in the City of Cleveland, ten minutes' ride from the heart of the city, and is served by switch tracks of the New York Central and Pennsylvania railroads. The company also owns at Elyria, Ohio, twenty miles from Cleveland, twenty-five acres of land, on which is situated a modern and completely equipped iron and bronze foundry.

Industrial Works was founded in 1873 by George C. Kimball, James Clements, E. Wells, and Charles R. Wells. Mr. W. L. Clements of Bay City was President from 1891 until his retirement in 1924, since which time Mr. E. B. Perry was President until his death on August 7th last. This company designs and builds locomotive cranes, wrecking cranes, heavy duty and full revolving pile drivers, crawler cranes and shovels for gasoline, steam, electric, or Diesel operation, gantries, pillar cranes, rail saws, buckets, and steam hammers. It also manufactures large coke oven machinery, including coke pushers, coal chargers, and clay carriers. The Industrial Works' plant covers twenty-nine acres, consists of sixty buildings, has over 440,000 sq. ft. of covered floor space, and is served by five miles of its own railroad track, with motive power and rolling stock for internal transportation facilities. The plant is complete, having its own steel, iron, and brass foundries, pattern shop, machine shop, structural shop, boiler and blacksmith shops, and all other departments necessary to build its product from the ground up.

The consolidation will join under one management over twenty-one hundred people, and assets of approximately $13,000,000. The combined sales of both companies totaled over $7,700,000 in 1926. Both plants will be continued in operation, and no radical changes of any sort are contemplated.

Use of Radio in Survey Operations in Canada

Excellent results in longitude determination as now being obtained by radio-telegraphy in the survey work of the Department of the Interior, Canada.

The longitude of any desired point may be derived from the known longitude of some other point by the simple process of adding to or substracting from the known longitude the difference in sideral (astronomic) time expressed in terms of arc, which is found to exist between the two points. Simple though this operation is in theory, in practice it involves the necessity of being able to compare the times in two distant places at the same instant. Such an instantaneous comparison of times could only be made in the past by telegraphic methods and relatively few places where the surveyor operates are connected by telegraph line. According to "Natural Resources, Canada," radio telegraphy has provided a solution to the problem, and has greatly enlarged the scope of astronomical work generally.

The Ohio Transportation Survey

Digest of Report of Cooperative Studies of U. S. Bureau of Public Roads and Ohio State Highway Department Given in June Public Roads

By J. GORDON McKAY

Chief of the Division of Highway Economics, U. S. Bureau of Public Roads

The report of a survey of transportation on the state highway system of Ohio has recently come from the press. This report contains the results of highway-traffic studies of the State, county and township road systems of Ohio conducted during 1925 under a cooperative agreement between the Bureau of Public Roads, United States Department of Agriculture, and the Ohio State Department of Highways and Public Works.

The investigation was undertaken in order to obtain essential facts concerning traffic on Ohio highways as a basis for planning the development of the Ohio State highway system to serve present and future traffic.

The conclusions are based upon the present density, type, loading, and distribution of traffic units and a traffic classification of State highways, upon present population and population trends, upon predicted future traffic, and upon an economic and physical analysis of other factors affecting the planning of a program of highway improvement.

The highway-traffic studies upon which the report is based were conducted under the joint supervision of Thomas H. MacDonald, Chief of the Bureau of Public Roads, and George F. Schlesinger, director, and L. A. Boulay, former director of the Ohio State Department of Highways and Public Works. J. Gordon McKay, Chief of the Division of Highway Economics, Bureau of Public Roads, directed the work of the survey and preparation of the report, assisted by O. M. Elvehjem, E. T. Stein, L. E. Peabody, and B. P. Root, all of the Division of Highway Economics, and Harry J. Kirk, State highway engineer, and Harry E. Neal, traffic engineer of Ohio.

Of the approximately 11,000 miles of state highways on January 1, 1926, there were 5,194 miles that were improved with brick, concrete, asphalt, and bituminous-macadam surfaces, of which more than half had surfaces less than 18 feet in width, and approximately 400 miles were old and worn-out pavement under county maintenance. Surface-treated macadam surfaces, of which there were 1,307 miles in 1925, will require re-treatment or reconstruction when the traffic materially increases. The remainder comprised 3,000 miles of gravel, slag, and stone and 1,282 miles of unimproved highways.

The principal problems now confronting the state are the reconstruction of the old, worn-out surfaces, expensive to maintain, the widening of narrow pavements, the improvement of unimproved sections of the state system, the elimination of the most dangerous railroad grade crossings, and the distribution of present highway revenues satisfactorily to complete the State system of roads.

Anticipating the need for a definite program of reconstruction and development, and realizing the necessity of having as a basis for a sound plan of highway improvement accurate data with respect to the traffic on the various sections of the State highway system, the Director of Highways and Public Works entered into an agreement with the United States Bureau of Public Roads to conduct a cooperative survey of transportation on the highways of the State.

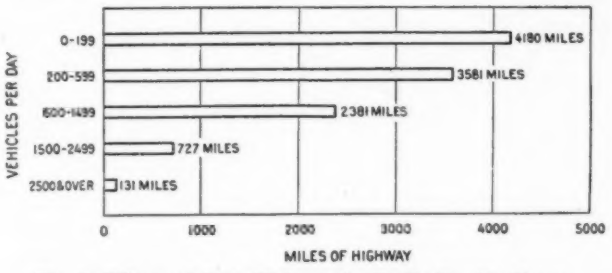


Fig. 1—Mileage of State Highways by Traffic Density Classes

Conclusions from Survey Summarized.—The results of the survey show that during the next five years the state should reconstruct 1,220 miles of the state system, widen 1,594 miles, and build 1,707 miles, the latter comprising 1,007 miles of construction superior to gravel and 700 miles of traffic-bound improvements. The cost is estimated at $100,000,000.

On the basis of the traffic observed during the survey, it is estimated that the state highway system, which comprises 13 per cent of the total rural mileage, provided highway service for a traffic of 2,160,435,000 vehicle-miles, equal to 57.7 per cent of the total motor-vehicle traffic on the rural highways of the state in 1925; that the county highways, which include 27.1 per cent of the rural mileage, provided service for 1,108,870,000 vehicle-miles, 29.6 per cent of the total traffic; and that the township highways, which constitute 59.9 per cent of rural mileage, provided service for 477,055,000 vehicle-miles, or only 12.7 per cent of total rural traffic. The daily traffic on the state system averages over nine times that upon the county and township roads. These facts show the necessity of allotting a sufficient portion of total highway revenues to complete the improvement of the state system of highways.

It is clearly shown by the survey that the principal routes of the state system, comprising what are known as the federal-aid and main market systems, are with a few exceptions the most important traffic routes of the state. The improvement of these routes, however, has not up to this time been entirely consistent with their traffic importance. There are sections of gravel and old, worn-out surfaces, narrow 9 to 16 ft. pavements, as well as unimproved sections on these heavily traveled routes.

The largest volume of motor-vehicle traffic is found in the areas adjacent to large centers of urban population and on the main, through-traffic routes.

Of the 11,000 miles of state highway system, 1.2 per cent carried 2,500 or more motor vehicles per day, 7.8 per cent carried 1,500 or more, 29.4 per cent carried 600 or more, and 70.6 per cent carried less than 600 vehicles per day in 1925.

The northeastern part of the state is the most important traffic area and is also the region of densest population, motor-vehicle registration, and industrial development. The southwestern area is very close to the northeastern section in traffic importance. The northwestern and southeastern parts of the state are of least present and expected future traffic importance.

Motor-truck traffic is an important part of total traffic on the principal routes. On the state system in 1925, 2.7 per cent of the mileage carried 200 or more trucks per day, 5.7 per cent carried 150 or more, 13.1 per cent 100 or more, and 27.5 per cent carried 60 or more trucks per day. Based on the traffic forecast, it is expected that by 1935 over 1,300 miles of state highways will carry 200 or more trucks per day,

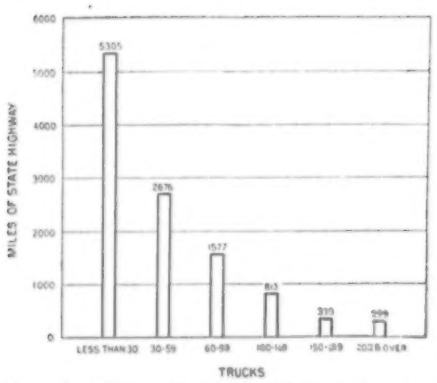


Fig. 2—Mileage of State Highways Carrying Various Numbers of Motor Trucks Per Day

while a comparatively small mileage is expected to carry from 500 to 1,000 trucks a day.

Four-fifths of the trucks operating on the state system are small units, 2½ tons capacity or less. The comparatively small number of large-capacity trucks and heavy loads observed may perhaps be attributed in a measure to the gross-load limitation of 20,000 pounds fixed by law in the state.

The average daily density of traffic in 1925 was 538 vehicles on the state system, 132 on county highways, and only 26 on township roads, each mile of road of the state system providing traffic service more than equal to that of 4 miles of county and 20 miles of town roads.

The federal-aid system, slightly more than half the state system, carried 70.6 per cent of the daily traffic of the state system; the main market roads, approximately one-third of the state system mileage and included for the most part in the federal-aid system, carried over half of the traffic, and the principal routes of the system, 8.8 per cent of the mileage, carried over one-fourth of the traffic.

Foreign traffic comprises but a small part of the total traffic except on the principal through-traffic routes. More than half of passenger-car traffic consists of cars used for business purposes.

The survey clearly shows that the traffic using the state system is predominantly city passenger-car and motor-truck traffic, farm-owned passenger cars and motor trucks making up only 12.4 per cent and 15.5 per cent, respectively, of the total passenger-car and motor-truck traffic. The improvement and maintenance of state highways is, therefore, primarily the result of the demand for highway service by city motor-vehicle owners.

The volume of traffic in a given area is principally produced by the population residing within a radius of 30 miles since less than 30 per cent of the truck traffic and less than 40 per cent of the passenger-car traffic travels more than 30 miles.

Future Traffic and Highway Requirements Estimated.—The distribution of population is an important factor in planning highway improvements. Of the entire area of the state 80 per cent has a population of less than 80 persons per square mile and is the home of only 22.7 per cent of the total state population, whereas the 9.4 per cent of the area that has a population of 160 or more persons per square mile includes 69.3 per cent of the population of the state.

These variations indicate marked differences in the necessity for highway service in the several parts of the state. In the densely populated areas the highway system should be planned to serve large volumes of traffic between the principal centers of population with tributary feeder routes connecting minor population centers with the primary traffic routes. These routes should be of sufficient width and improved with surfaces adequate to carry the large daily volume of traffic as directly as possible; obstructions to the free movement of traffic, such as railway cross-

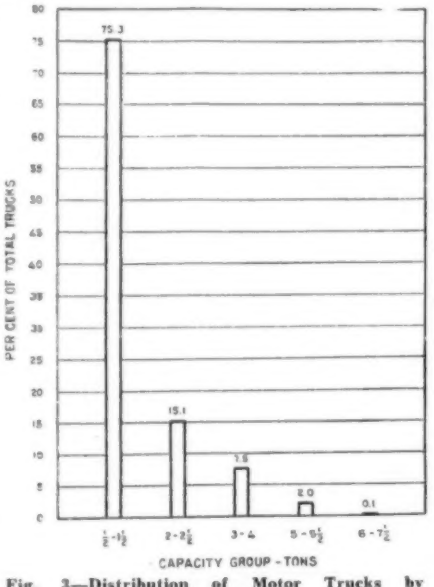


Fig. 3—Distribution of Motor Trucks by Capacity Groups

ings at grade, sharp curves, heavy grades, and congested traffic sections should be eliminated, and by-pass routes should be constructed to avoid the traffic congestion which occurs when a main traffic route passes through the business center of small villages and cities. In the sparsely populated areas the volume of traffic is smaller and its sources more scattered. A connected system of main routes comprising a smaller mileage, improved with gravel or the lower types of paved surfaces where traffic warrants such improvements, should satisfactorily meet traffic requirements in these areas, except on the main through routes traversing them. The removal of obstacles to the easy movement of traffic is not an important problem in areas of low population and traffic, particularly when the expectancy of future traffic increase is small.

The density of traffic on the various roads of the state system has been used as the basis for an estimate of traffic on the same roads in 1930 and 1935, applying for this purpose the relation between the increase in traffic on the highways and the ratio of population to motor-vehicle registration observed in other states. In 1925 there was one motor vehicle for each 4.7 persons in Ohio. Extending the past trend of this ratio to 1935 it is estimated that there will then be one vehicle for each 2.82 persons. On this basis the registration of 1935 is estimated at 2,607,000 motor vehicles, a registration approximately twice as great as that of 1925. As the yearly increase of motor-vehicle traffic on the highways has been found to be practically in direct proportion to the growth of motor-vehicle registration, it may be expected that traffic on the state highways will increase 51 per cent between 1925 and 1930, and 28 per cent between 1930 and 1935.

As a basis for the plan of highway improvement, the state highways are classified in three groups designated as major, medium, and minor traffic highways, according to their average daily traffic. Routes or sections of routes carrying 1,500 or more motor vehicles per day are classed as major routes, those carrying 600 to 1,500 vehicles per day as medium routes, and those carrying less than 600 vehicles daily are classed as minor routes. The routes or sections of routes are classed in this way on the basis of the observed 1925 traffic, and the estimated traffic for 1930 and 1935 is employed in a similar manner to indicate the probable classification in those years.

Experience in many states indicates that ordinary untreated gravel and similar surfaces can not be economically maintained when the traffic exceeds 500 to 600 vehicles per day, and similar experience in Ohio points to approximately 600 vehicles per day as the limit. Above that traffic density the type and design of surface required are largely functions of the frequency of heavy loads, the choice of types including bituminous macadam for the lower densities and the several rigid types for roads of greater density.

If, on the basis of this experience, those sections of the Ohio state system

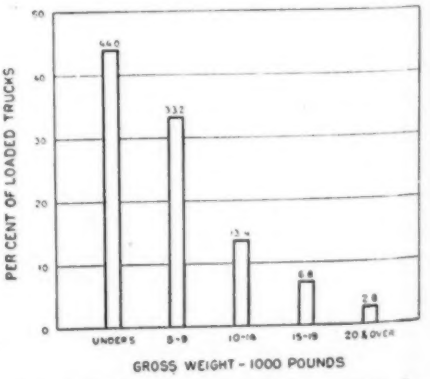


Fig. 4—Distribution of Motor Trucks by Gross-Weight Groups

which carry a traffic of 600 or more vehicles per day be considered as requiring a type of surface superior to untreated gravel, it is found that in 1925 over one-third of the 11,000 miles of the state system, or 3,852 miles, required such surfaces, and 10 years later, in 1935, based on the estimated traffic, approximately half the system, or 5,221 miles, should be so improved.

The Methods of the Survey.—The traffic survey was begun in December, 1924, and continued for a period of one year. During the survey traffic data were recorded at 1,158 points on Ohio highways. At 358 of these points complete data were recorded one day each month during the year period. At the remaining 800 points counts of passenger cars and motor trucks were obtained on three days during the summer months. Data obtained included counts of passenger cars, motor trucks, motor busses, horse-drawn vehicles, foreign vehicles, and detailed truck and passenger-car data. Motor-truck data included the capacity of the truck, state of registration, place of ownership, origin, destination, type of origin and destination, commodity carried, and tire equipment. At alternate operations at 156 stations total gross and rear-axle weights were measured by means of portable scales. Passenger-car data included state of registration, status of ownership, purpose of trip, origin, destination, and number of passengers.

Each operation consisted of a 10-hour observation period, alternating between 6 a. m. to 4 p. m. and 10 a. m. to 8 p. m. Special observers tabulated traffic between 8p. m. and 6 a. m. at selected stations. Complete 24-hour observations were therefore available at these stations, which were made the basis of computation of hourly variations in traffic and of average daily traffic at all stations. Traffic observations for week periods were also made at selected stations to determine variations in traffic by days of the week. Seasonal variations were computed from the monthly operations at all stations. Stations were operated on a carefully planned schedule which permitted operations on the various days of the week and prevented duplicate recording of traffic.

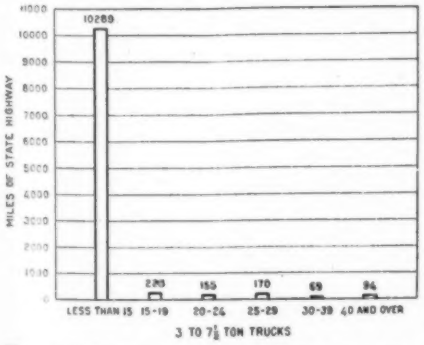


Fig. 5—Mileage of State Highways Carrying Various Numbers of 3 to 7½-Ton Trucks

Traffic was observed on practically all sections of the state highway system, and stations were so located as to enable close observation of the variations in traffic on various routes and sections of routes. Stations were also located on representative sections of the county and township highway systems in all sections of the state.

State System Carries Large Percentage of Total Traffic.—There are in Ohio approximately 84,884 miles of rural highway, of which on Jan. 1, 1926, 11,000 miles were intercounty highways, constituting the state highway system. Of the remaining 73,884 miles, 22,991 were included in the county system, and 50,893 were township roads. Federal-aid highways included in the state highway system aggregated 5,899 miles and the main market road system 3,486 miles.

Upon the 84,884 miles it is estimated that in 1925 there was a motor-vehicle movement of approximately 3,746,360,000 vehicle-miles. The relative importance of the state highway system is indicated by the fact that although it includes but 13 per cent of the entire

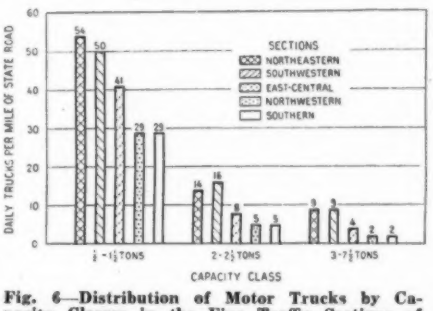


Fig. 6—Distribution of Motor Trucks by Capacity Classes in the Five Traffic Sections of the State

rural road mileage, it carried 2,160,435,000 vehicle-miles, or 57.7 per cent of the total motor-vehicle traffic during 1925. The average daily motor-vehicle traffic per mile upon the state highway system is over nine times that upon the county and township roads.

The daily volume of traffic on different parts of the state highway system varies widely. The number of motor vehicles per average 24 hour day varied from 5,583 on route U. S. 30, between Canton and Massillon, to a minimum of less than 20 vehicles on several unimproved sections. The state highway system includes 4,180 miles, on which the average daily motor-vehicle traffic per mile was less than 200 vehicles. County and town roads include a considerable mileage, on which the average daily traffic was less than 5 vehicles per day.

During 1925 the density of horse-drawn vehicles was recorded at all survey stations, but it was early apparent that their numbers were so few as to warrant no consideration in highway planning. The average traffic of horse-drawn vehicles on state highways is less than 7 per day.

Motor-bus traffic is important on several of the state routes. It is, however, a specialized movement, and its volume on any highway is the product of several factors which have little effect upon other motor-vehicle traffic. Motor-bus traffic is, therefore, discussed separately in the report, and the term "motor-vehicle traffic" refers only to passenger cars and motor trucks.

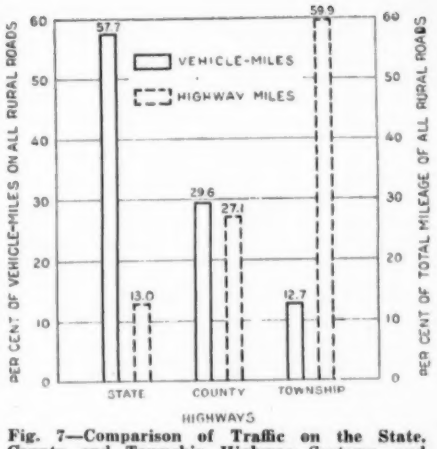


Fig. 7—Comparison of Traffic on the State, County and Township Highway Systems, and the Proportionate Mileage of the Three Systems

The complete report shows the traffic density at each of the 1,158 points where traffic was observed during the survey and shows also, by counties, the routes upon which traffic was observed, the average density of motor-vehicle traffic for a 24-hour day, the average daily density of motor-truck traffic, the normal maximum traffic, and the estimated traffic for 1930.

Principal Traffic Routes.—The largest volume of traffic of both passenger cars and trucks is found in the areas adjacent to large centers of urban population and on the main through routes.

The concentration of traffic in the areas immediately adjacent to the larger cities of the state is apparent. The principal through routes are also clearly evident as broad bands serving wide areas in the State and connecting the important cities of Ohio and nearby States. The traffic importance of these principal routes is the result of local traffic of the area augmented by the traffic moving between larger centers of population.

The system of numbered United States highways in Ohio when improved will form a well-balanced network of the more important through-traffic highways of the State. Many of these routes will serve a large volume of local traffic. The total traffic on each route will depend very largely upon the population and development of the immediate areas which it traverses, and traffic upon those routes which pass through the sparsely populated sections of the state will continue to be small as compared with those routes which connect the important sources of local traffic.

Of the 11,000 miles of the state highway system, 131 miles, or 1.2 per cent

of the total mileage, carried 2,500 or more motor vehicles per day in 1925; 858 miles, 7.8 per cent of the system, carried 1,500 or more; 3,239 miles, approximately 30 per cent of the total, carried 600 or more; and 7,761 miles, 70.6 per cent, carried less than 600 vehicles per day, of which 4,180 miles carried less than 200, as shown in Figure 2.

The routes carrying the largest daily volume of traffic are with few exceptions in the northeastern, northern and southwestern parts of the State, and the routes of least traffic importance are in the southeastern and northwestern sections.

On the basis of traffic the State is divided into five separate traffic sections, each of these sections being subdivided in the order of their traffic importance into two or more divisions, somewhat comparable with the distribution of population and industry. Table I shows the mileage of State highways, by traffic classes, in the five traffic sections.

Truck Traffic an Important Factor.—Although motor-truck traffic on the state highway system is only 9.5 per cent of total motor-vehicle traffic measured in vehicle-miles, motor-truck traffic is an important factor in highway-traffic planning.

The average gross weight of motor trucks using the state system is over twice that of passenger cars, while maximum motor-truck weights are four times the maximum weights of passenger cars. The importance of the motor truck is further emphasized by the fact that many trucks are equipped with cushion and solid tires, which are much less effective in cushioning the impact of the wheels than the pneumatic tires with which the passenger cars are equipped. A study of the rear-wheel tire equipment of motor trucks using the state highway system shows that 15 per cent of all the trucks are equipped with solid tires and a like percentage with cushion tires, and that 95 per cent of the 3 to 7½ ton trucks are equipped with cushion or solid tires on the rear wheels.

Since motor trucks carry heavier gross loads than passenger cars, and the larger capacities are equipped with solid or cushion tires, and because the trucks do not have the refinements in shock-absorbing devices and spring equipment possessed by the passenger cars, the motor truck, where it forms an appreciable part of motor-vehicle traffic, presents a special problem for the highway builder.

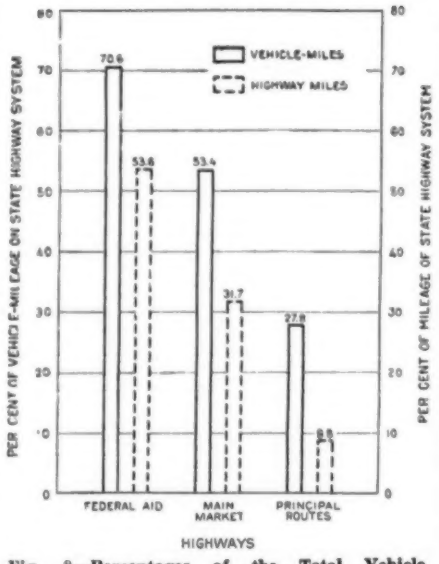


Fig. 8—Percentages of the Total Vehicle Mileage on the Intercounty System That Is Carried by the Federal-Aid and Main Market Highways and by the Principal Routes of the State, and the Mileage of the Several Classes of Highways

The average daily density of motor-truck traffic varies greatly on different routes and in various parts of the state. Of the 11,000 miles of state highways, 299 miles, 2.7 per cent of the total, carried in 1925, 200 or more trucks per day; 629 miles, 5.7 per cent, carried 150 or more; 1,442 miles, 13.1 per cent, carried 100 or more, 3,019 miles, 27.5 per cent, carried 60 or more; and 7,981 miles, 72.5 per cent, carried less than 60 trucks, of which 5,305 miles, 48.2 per cent, carried less than 30, as shown in Fig. 2. On routes carrying a small average daily truck traffic, especially those on which there are less than 30 trucks, and many sections on which the daily density ranges from 30 to 59 class the number of trucks is practically negligible in planning highway improvements. An improvement sufficient for passenger-car traffic will, with but few exceptions, prove satisfactory for the small-capacity trucks using these routes. On those routes carrying 60 or more, and particularly the routes carrying 100 or more, the motor truck becomes an important factor in planning the improvement of the highways.

Sections of highway which have a traffic of more than 200 trucks per day include 299 miles, or 2.7 per cent, of the total state highway mileage. On the basis of the traffic forecast there will be 841 miles of state road in 1930 and 1,351 miles in 1935, on which the motor-truck traffic density will exceed 200 trucks per day.

U. S. route 30, Massillon to Canton, carries an average of 485 trucks per day, which is the highest truck density on any section in the state. In the forecast for 1935, truck traffic on this route is estimated at 1,000 per day. Highway sections carrying from 150 to 200 trucks per day comprise 330 miles, or 3 per cent, of the total mileage of state highways.

Cities Influence Truck Traffic.—The more important of the five traffic sections shown in Table I, from the standpoint of motor-truck density, are the northeastern section, where the average daily density of motor trucks is 77 per mile of state highway, and the southwestern section with a density of 75 trucks. The corresponding density is 53 in the east-central section, and 36 in the northwestern and southern sections.

The comparative importance of the northeastern section is further emphasized by the fact that this section includes 25 per cent of the total mileage of state highways. The southwestern section, although of almost equal truck traffic density, includes only 7 per cent of the mileage of state highways. The northwestern and southern sections, with a density of only 36 trucks per day, include 56 per cent of the state highway mileage.

The size, location and industrial development of cities and towns determines very largely the volume of motor trucking on routes in the several sections of the state. Centers of population and industry are the main source and destination of goods transported by motor truck, and the principal trucking routes are those serving the territory adjacent to the larger cities and those routes connecting centers of population.

The influence of large cities on motor-truck traffic is clearly shown by the data collected. The nine largest cities in the state, in order of population, are Cleveland, Cincinnati, Toledo, Columbus, Akron, Dayton, Youngstown, Canton and Springfield. Around these cities, with one or two exceptions, is found the greatest volume of motor-truck traffic. The influence of large cities upon truck traffic in the five sections of the state is shown in Table II.

It is apparent that the high density of truck traffic per mile on the state roads of the northeastern and southwestern sections is caused by the large cities in these areas. The two sections, which together include 30 per cent of the total area of the state, include 58 per cent of the cities of over 10,000 population. The northwestern and southern sections, the least important regions of truck traffic, contain 58 per cent of the area and include only 24 per cent of the cities of over 10,000 population.

The more important trucking areas,

Table I.—Mileage of State highways, by traffic classes, in the five traffic sections

Section	All State highways		Daily traffic, over 1,500 vehicles		Daily traffic, 600 to 1,500 vehicles		Daily traffic, less than 600 vehicles	
	Miles	Per cent of total miles	Miles	Per cent of total miles	Miles	Per cent of total miles	Miles	Per cent of total miles
Northeastern	2,821	25.6	454	52.9	836	35.1	1,536	19.8
Southwestern	736	6.7	133	15.5	202	8.5	401	5.2
East-central	1,285	11.7	86	10.0	265	11.1	934	12.0
Northwestern	3,402	30.9	162	18.9	679	28.5	2,556	32.9
Southern	2,756	25.1	23	2.7	399	16.8	2,334	30.1
State total	11,000	100.0	858	100.0	2,381	100.0	7,761	100.0

the northeastern and southwestern sections, have five of the seven cities between 30,000 and 100,000 population, and six of the seven cities of over 100,000 population. Cleveland in the northeast and Cincinnati in the southwest are the predominating traffic influences in these two regions.

The motor-truck registration per square mile, shown in Table II, indicates the concentration of trucks in the southwestern and northeastern sections.

Table II—Average Truck-Traffic Density on State Roads in the Five Traffic Sections of the State Compared with the Relative Area of the Sections, Their Truck Registration Per Square Mile, and the Number of Cities Over 10,000 Population in Each

Section	Average truck-traffic density	Percentage of total area in the state	Truck registration per square mile (1924)	Cities over 10,000 population, by population classes* Total Number	Total Per cent	10,000 to 30,000	30,000 to 100,000	Over 100,000
Northeastern	77	24	7.9	22	44	15	3	4
Southwestern	75	6	10.9	7	14	3	2	2
East-central	53	12	2.5	9	18	9	..	..
Northwestern	36	30	2.3	7	14	5	1	1
Southern	36	28	1.3	5	10	4	1	..
Total	51	100	3.9	50	100	36	7	7

*United States census of 1920.

The comparatively low registration per mile in the three remaining sections, especially in the southern section, again reflects the relatively small number of large centers of population and industry and accounts for the lower truck-traffic density in these areas.

Figure 3 shows the distribution of motor trucks by capacity groups, Fig. 4 the distribution of loaded motor trucks by gross-weight groups, Fig. 5 the mileage of state highways carrying various numbers of 3 to 7½ ton trucks, and Fig. 6 the distribution of motor trucks by capacity classes in the five traffic sections of the state.

It is possible that the high density of motor-truck traffic in the important traffic areas of the state will eventually present problems difficult of solution. Routes having a large number of motor trucks also carry a large number of passenger cars. On such routes, unless supplementary highway facilities are provided, serious congestion problems will develop. The mileage subject to this danger is not large. In 1925 there were only 15 miles of state highway on which the density of motor-truck traffic exceeded 400 trucks per day and only 87 miles where the daily density was greater than 300 trucks.

Table III—Motor-Vehicle Utilization and Mileage of Ohio Rural Highways, by Systems*

Highway system	Mileage	Per cent of total mileage	Daily vehicle-miles	Annual vehicle-miles	Per cent of total vehicle-miles	Average daily traffic density
State highways	11,000	13.0	5,919,000	2,160,435,000	57.7	538
County highways	22,991	27.1	3,038,000	1,108,870,000	29.6	132
Township highways	50,893	59.9	1,307,000	477,055,000	12.7	26
Total	84,884	100.0	10,264,000	3,746,360,000	100.0	.....

*Motor vehicles refer to passenger cars and trucks only, excluding motor busses.

Table IV—Motor-Vehicle Utilization and Mileage of Ohio Rural Highways in the Five Traffic Sections

Highway systems and sections of state	Mileage of highways	Per cent of highway mileage	Daily vehicle-miles	Per cent of daily vehicle-miles	Average daily density of traffic
State highways:					
Northeastern	2,821	25.6	2,268,000	38.3	804
Southwestern	736	6.7	571,000	9.6	776
East-central	1,285	11.7	650,000	11.0	506
Northwestern	3,402	30.9	1,478,000	25.0	434
Southern	2,756	25.1	952,000	16.1	345
Total	11,000	100.0	5,919,000	100.0	538
County highways:					
Northeastern	5,916	25.7	1,128,000	37.1	191
Southwestern	1,788	7.8	353,000	11.6	197
East-central	2,654	11.6	319,000	10.5	120
Northwestern	7,547	32.8	814,000	26.8	108
Southern	5,086	22.1	424,000	14.0	83
Total	22,991	100.0	3,038,000	100.0	132
Township highways:					
Northeastern	10,625	20.9	428,000	32.8	40
Southwestern	2,579	5.1	102,000	7.8	39
East-central	7,372	14.5	184,000	14.1	25
Northwestern	14,889	29.2	326,000	24.9	22
Southern	15,428	30.3	267,000	20.4	17
Total	50,893	100.0	1,307,000	100.0	26
All highways:					
Northeastern	19,362	22.8	3,824,000	37.3	197
Southwestern	5,103	6.0	1,026,000	10.0	201
East-central	11,311	13.3	1,153,000	11.2	102
Northwestern	25,838	30.5	2,618,000	25.5	101
Southern	23,270	27.4	1,643,000	16.0	71
State total	84,884	100.0	10,264,000	100.0	121

The relief of congestion which will probably result on a few sections of the state system undoubtedly lies in increasing the width of road and creating separate lanes for truck traffic or in the construction of parallel routes. In either case the segregation of passenger-car and motor-truck traffic would speed up passenger-car traffic and eliminate congestion caused by heavy, slow-moving vehicles.

Highway Utilization.—During 1925 traffic of passenger cars and trucks on the 84,884 miles of rural highways in Ohio was approximately 3,746,300 vehicle-miles. The distribution of traffic varies greatly on the several highway systems, on sections of each system, and in the several traffic areas of the state. The three classes into which the rural highways of the state are divided are state highways, of which there are 11,000 miles, county highways, which total 22,991 miles, and township highways, of which there are 50,893 miles. The distribution of vehicle mileage on each of these systems or their traffic use is shown in Table II and Fig. 7.

The state highway system, 13 per cent of the rural highway mileage, carries 57.7 per cent of the traffic measured in vehicle-miles. Contrasted with this system is the township highway system with 59.9 per cent of the highway mileage and only 12.7 per cent of the vehicle mileage.

The average daily density of traffic on the state system is 538 vehicles, on the county system 132, and on township roads only 26.

The distribution of highway mileage and vehicle mileage by highway systems in each of the five sections of the state is shown in Table IV.

The state highways in the northeastern section of the state, comprising 25.6 per cent of the state highway mileage, carry 38.3 per cent of the total traffic on the state highway system. In the southwestern section there is 6.7 per cent of the state highway mileage which carries 9.6 per cent of total traffic on the system. In contrast with these areas is the southern section, with 25.1 per cent of the state highway mileage and only 16.1 per cent of the total traffic on the system. Variations in traffic on the county and township system in the five regions are almost equally pronounced.

Traffic on the state highway system also varies greatly on the different routes, ranging from more than 5,500 vehicles per day on the heaviest route observed to less than 50 vehicles per day. The daily use of selected sections of the state highway system is shown in Table V and Fig. 8.

The Federal-aid system, slightly more than half the state system, carries 70.6 per cent of the daily traffic; main market roads, approximately one-third the mileage, carry over half the traffic; and the principal routes, 8.8 per cent of the mileage, carry over one-fourth of the traffic. These divisions of the state highway system indicate clearly the variation in traffic on this system.

The distribution of passenger-car and

motor-truck traffic on the different highway systems is shown in Table II.

Motor-truck traffic on the township system, and to a lesser degree on the county system, is almost exclusively made up of small-capacity trucks, while on the state system it includes a larger proportion of medium and large capacity trucks.

Table V—Average Daily Traffic on Selected Sections of the State Highway System

Sections of system	Highway miles	Per cent of state highway system	Per cent of total rural highway system	Average daily vehicle-miles	Per cent of daily vehicle-miles on state highway system	Per cent of daily vehicle-miles on all rural highways	Average daily density of traffic
Federal-aid system*	5,899	53.6	6.9	4,177,000	70.6	40.7	708
United States highways	1,878	17.1	2.2	1,848,000	31.2	18.0	984
Main market roads	3,486	31.7	4.1	3,158,000	53.4	30.8	906
Selected principal routes	976	8.8	1.1	1,645,000	27.8	16.0	1,696
State highway system	11,000	100.0	13.0	5,919,000	100.0	57.7	538

*With few exceptions the Federal-aid system includes all United States highways and main market highways as well as the roads designated as principal routes.

Figure 9. The great variations in industrial and agricultural development, in population, in motor-vehicle registration, and in the period of the series apparently have had no effect upon the relationship between the rates of traffic increase and motor-vehicle registration growth.

Table VI—Motor-Truck and Passenger-Car Utilization of Ohio Rural Highways, by Systems

System	Daily truck-miles	Per cent of total truck-miles	Daily passenger-car miles	Per cent of total passenger-car miles	Ratio of truck-miles to total vehicle-miles
State highways	565,000	54.1	5,354,000	58.1	9.5
County highways	332,000	31.8	2,706,000	29.3	10.9
Township highways	147,000	14.1	1,160,000	12.6	11.2
Total	1,044,000	100.0	9,220,000	100.0	10.2

There is also considerable variation in the relative number of passenger cars and trucks on different routes of the state highway system. Motor trucks vary from less than 6 per cent to more than 20 per cent of total number of vehicles. The extremes of the range are found on routes of minor traffic importance; on nearly all the important traffic routes the percentage falls between 7 and 11. Passenger cars are found to be relatively more important on the principal through routes, and the greatest proportion of trucks is found on important routes in the industrial areas which are not a part of these through routes.

Forecast of Highway Traffic.—A knowledge of future traffic, in so far as it can be predicted with reasonable accuracy, is essential in the establishment of a sound plan of highway improvement. A forecast based directly upon past traffic trends is not possible, since there is no historical series of highway traffic records in Ohio. Such records are available in the States of Maine, Maryland, Massachusetts, Michigan, and Wisconsin. Highway traffic and motor-vehicle registration in each of these states have increased at approximately equal rates, as shown in Figure 9. The great variations in industrial and agricultural development, in population, in motor-vehicle registration, and in the period of the series apparently have had no effect upon the relationship between the rates of traffic increase and motor-vehicle registration growth.

In the absence of any comprehensive historical series of traffic records in Ohio it has therefore been assumed that highway traffic in Ohio is increasing directly with the increase in motor-vehicle registration.

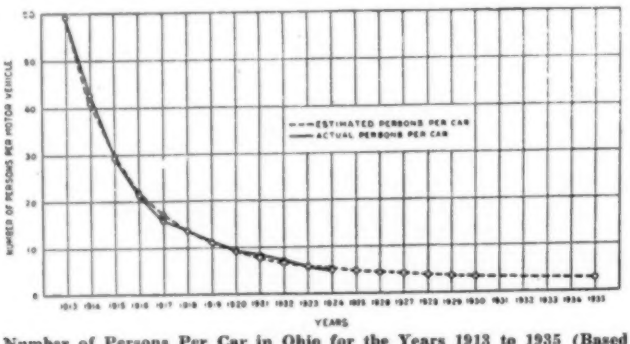


Fig. 9—The Number of Persons Per Car in Ohio for the Years 1913 to 1935 (Based on Estimated Population for Intercensal Years)

The increase of motor-vehicle registration is a function of two variables: (1) The increase in population, and (2) the increase in ownership and use of motor vehicles in proportion to population, measured by the number of persons per motor vehicle. The past trend of both of these factors may be determined from available records.

Population changes are measured accurately by the decennial census and intercensal estimates made by the Bureau of the Census. Population, by years, as estimated by the Bureau of the Census, from 1913 to 1923 and estimates calculated by extension of the census method for 1924 to 1930 and for 1935 is shown in Table VII.

The growth of motor-vehicle registration in proportion to population, i. e., the decrease in persons per car, appears to follow the same general characteristics as the growth of population, an early growth slow in number of vehicles but rapid in rate of increase followed by a gradual decrease in the rate of growth.

The number of persons per car in Ohio during the years 1913 to 1925 and the extension of the trend of persons per car to 1935 is shown in Fig. 10. The estimated number of persons per car for each year is shown in Table VII.

Combining estimated population and estimated number of persons per car for each year, the predicted registration for each year is obtained. These estimates are also shown in Table VII.

Table VII—Comparison of Population and Number of Motor Vehicles in the State of Ohio

Year	Registration (thousands) Actual	Registration (thousands) Estimated	Population* (thousands)	Persons per car Actual	Persons per car Estimated
1913	86	86	5,095	59.24	59.24
1914	123	127	5,197	42.00	40.92
1915	181	179	5,299	29.28	29.60
1916	252	245	5,402	21.44	22.05
1917	347	324	5,504	15.86	16.99
1918	413	416	4,606	18.57	13.48
1919	511	521	5,708	11.17	10.96
1920	621	637	5,810	9.36	9.12
1921	721	763	5,913	8.20	7.75
1922	859	897	6,015	7.00	6.71
1923	1,069	1,038	6,117	5.72	5.89
1924	1,242	1,181	6,219	5.01	5.27
1925	1,346†	1,329	6,321	4.70	4.76
1926	1,480†	1,475	6,424	.....	4.36
1927	.....	1,621	6,526	.....	4.03
1928	.....	1,763	6,628	.....	3.76
1929	.....	1,902	6,730	.....	3.54
1930	.....	2,035	6,833	.....	3.36
1935	.....	2,607	7,344	.....	2.82

*Population as of July 1 of each year.
†Data not available when forecast was made. Estimate differs by 1.3 per cent from actual value in 1925, and by 0.3 per cent in 1926.

On the basis of these predictions it is estimated that motor-vehicle registration in 1930 will be 2,035,000, with 3.36 persons per car, and in 1935, 2,607,000, with 2.82 persons per car. The increase in motor-vehicle registration between 1925 and 1930 is therefore expected to be 51 per cent and the increase between 1930 and 1935, 28 per cent.

The rate of population change varies greatly in different sections of the state, as does also the present number of persons per car.

The rates of decrease in persons per car within these areas, however, fol-

low the same principle and are therefore in close agreement.

To allow for differences in the rate of population change and for differences in the present number of persons per car in the various sections of the state, the number of persons per car, based on estimated population and actual motor-vehicle registration in 1925, was obtained for each county of the state. To this 1925 value for each county was applied the rate of decrease in persons per car for the state between 1925 and 1930. The estimated registration for each county in 1930 was calculated by applying the estimated number of persons per car in 1930 for each county to the estimated 1930 population of that county. From the actual county registration in 1925 and the estimated registration in 1930 the percentage increase in registration for the county was computed. This method results in the same total for the state and reflects differences in motor-vehicle registration in 1925 as well as differences in rates of population growth in the 88 counties. The expected county registration growth, 1925 to 1930, varies from 41.3 to 74.9 per cent, the latter rate resulting from a rapid rate of population increase.

Since traffic increases at the same rate as motor-vehicle registration, the expected traffic at each survey station was determined by applying the county rate of registration increase to each traffic station in the county. The resulting forecast of traffic at each station is shown in the appendix of the full report.

Industrial and suburban development, as well as changes affecting the present highway system as to location of routes, routing of traffic, and detours and conditions of improvement influence traffic on short sections of highway, and it is not expected that these estimates will in all cases reflect exactly the actual traffic in 1930, but it is believed that they will reflect with reasonable accuracy highway traffic on the state highway system as a whole.

In certain areas, particularly areas of sparse population adjacent to centers of population, a very important part of the traffic originates in the centers of population. In such cases a traffic forecast based on the population and motor-vehicle registration in the sparsely populated area will not reflect the influence of traffic originating outside the county boundaries.

To allow for such variations, and also because population estimates based on arithmetical progressions are less accurate when applied to smaller areas and when forecasted over a greater number of years, the traffic forecast for 1935 was computed on the basis of the state increase in registration between 1930 and 1935 rather than for increases in each county. The 1935 forecast therefore represents an increase of 28 per cent over the forecast in 1930 for all sections of the state. Because of the longer period of time and the greater probability of changes in the rate of population growth in motor-vehicle use and in changes in the state highway system, the traffic forecast for 1935 is expected to be less accurate than the forecast for 1930. It has therefore been applied to highway sections rather than to individual points and is expected to reflect traffic conditions in 1935 within the limits of accuracy required in the establishment of a sound plan of highway improvement.

Capping Square for Concrete Compressive Strength Specimens

The road materials testing laboratory of the Missouri State Highway Department has for some time been using a device for capping concrete cylinders for compression tests which gives the specimens a uniform bearing and at the same time permits the work to be done rapidly. The device is described in "Public Roads" by F. V. Reagel, Engineer of Material, Missouri State Highway Department.

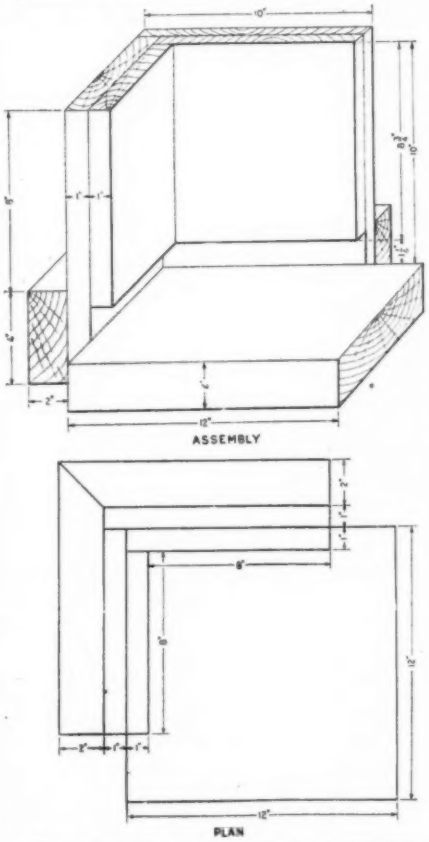


Fig. 1—Details of Construction of Capping Square

The device was developed by A. D. Conrow, formerly assistant testing engineer and now employed in the same capacity by the Kansas Department of Highways. Comments of visiting engineers have indicated that the method which has been developed will be of general interest to testing engineers.

Figure 1 shows the details of designs of the apparatus, and with this guide it can be constructed at small expense. Well-seasoned wood should be used for constructing the framework to prevent warping, and the inside faces are lined with 16-gauge metal. The slot shown just above the base is to receive a square metal plate, from ⅜ to ½ in. in thickness, on which the specimens are capped. For convenience in handling, three rivet or bolt heads are inserted in the bottom of the plate.

Cylinders Capped Accurately and Rapidly.—The plate upon which the specimen is to be capped is first given the usual coating of oil to prevent sticking. Sufficient capping material for one cap plus a slight excess is then deposited upon the plate. The plate is shoved into the corner snugly, the groove at the bottom allowing the specimen to rest against the corner and still remain near the center of the plate. The specimen is lowered upon the capping material with a rotating motion under considerable pressure, the motion finally ending with the specimen resting snugly against each side of the corner of the capping square. The rotating motion serves to squeeze out the excess capping material which is rapidly worked up around the outside of the specimen. A large trowel is then inserted under the plate and the plate and specimen set aside until the cap has hardened.

As soon as the cap has sufficiently hardened the plate is loosened by tapping lightly against the edge, and the process is repeated with the other end of the specimen upon the plate. Using this method, one operator can cap about 80 specimens on each end per day and the resulting specimens will have uniformly parallel ends.

The capping materials in use at present are a mixture of plaster of Paris and Portland cement for hand-cast specimens and a 1 to 3 mortar of Lumnite cement and sand for the more irregular field-drilled specimens.

On account of the extreme irregularity of some specimens drilled from pavements, this process is not always suitable for use in capping each end of the specimen. In such cases the metal collar is used. This collar is of 18-gauge metal and is provided with two wing-nut bolts by means of which the collar may be drawn tightly around the specimen. Capping material is then placed within the collar, building up the entire specimen to the height of the longest element plus the desired thickness of cap.

Delaware Makes 7,000 Tests

During the past year the Delaware State Highway Department tested more than 7,000 specimens. The cost of this inspection was less than one-quarter of 1 per cent of the cost of highway work done during that year. Core drills showed 70 per cent, with a thickness of one-half in. or more above contract thickness.

Economic Theory of Highway Location

Principles Used in the Design of the Location of the New Jersey Arterial Highway Discussed in Paper Presented at 3rd Annual Convention of the Association of Highway Officials of the North Atlantic States

By F. LAVIS
Consulting Engineer, New York City

It is presumed, of course, that much of what may be said about this subject may be familiar to those who have had experience in railway location, inasmuch as this economic theory of highway location is based on the economic theory of railway location long in use, but even among railroad men this nowadays is not a common experience, and I have been given to understand that many of those present have had little occasion to have been interested in this subject. It is not, therefore, necessary to offer apology for the more or less elementary character of part of what I have to say.

To the railroad men I shall hope to be able to point out some essential and very considerable differences in the application of this theory to highway location as compared with its application to railway location, and to the others I would call attention to the very urgent need of consideration of these economic factor in view of the ever-growing need of highways to meet very heavy traffic conditions, the very high cost of such highways, and the need of adequate and proper co-ordination of expenditures for construction, with traffic capacity and use.

Many of you may recall that the arterial highway is costing from $2,000,000 to as much as $5,000,000 for some miles, so that it will be realized that the economic design of its location is of as much, even of greater, importance than the design of the structures which compose it. The design of the location will affect the owner of every vehicle which passes over the road for an indefinite and probably very long time in the future, while the design of the structures while of course important, affects only a small proportion of the present expenditures distributed over the life of the structure.

Wellington Theory of Railway Location.—In order to present the subject understandingly to those who are not familiar with it, it seems necessary to first outline very briefly the Theory of Railway Location as developed by the late Arthur M. Wellington, who first fully developed it in the form used for so long by railway engineers.

Briefly then, this theory was a means of comparing two or more proposed locations by first estimating the cost of construction on each of them, then estimating the effect of the alignment or curvature, rate of gradient, rise and fall, and distance on the cost of operation of the trains which were expected to pass over the line.

In calculating effect on cost of operation of the several factors above alluded to, Mr. Wellington first determined the cost of operation per train mile and divided this into its various component parts, as follows:

	Per Cent of Total
Fuel	7.6
Water, oil and Waste	1.2
Repairs of engine	5.6
Switching-engine service	5.2
Train wages and supplies	15.4
Repairs of cars	10.0
Car mileage	2.0
Renewals of rails	2.0
Adjusting track	6.0
Renewing ties	3.0
Earthwork, ballast, etc.	4.0
Yards and structures	8.0
Stations and general	30.0
	100.0

He then proceeded to analyze what the effect on each of these items would be on each train for each foot of distance, degree of curvature and foot of rise and fall. For instance, additional distance means primarily the expenditure of additional power to haul the train over this additional length of line. The first items, fuel, water, oil and waste, are directly proportionate to the distance, other physical condition being the same. Then taking, for instance, the last item, stations and general expense, 30 per cent of the total, it is clearly evident that this is hardly affected at all by minor or even considerable changes in length of line. The item, wages of trainmen, might or might not be affected. If the differences in distance were so small that there were only a few minutes difference in the time necessary to get trains over the division, they would not affect wages of the train crews. If such differences, however were such as to involve overtime on certain classes of trains, this would mean appreciable additional costs of operation.

The effect of each item can be worked out for each train or each type of train, then multiplied by the number of trains, in order to get the total annual operating cost.

Mr. Wellington went into very minute detail in analyzing all these various items and their effect on operating costs, but for the purpose of this paper the above indication of the method seems all that is necessary, as details will be given further on in reference to the application of these methods to highway work.

Assuming, then, that the additional cost of operation due to each of the given items can be determined as they apply to distance, rise and fall, etc., a calculation can be made of the amount of money which could profitably be spent to avoid this cost.

Suppose, for instance, that it be determined that by reason of additional distance, curvature, or rise and fall, the cost of operation on one line will amount to, say, $100,000 a year more than on another, then if money can be borrowed or obtained at an interest rate of 5 per cent per annum, it would be profitable, if necessary, to spend as much as $2,000,000 additional on the construction of the better line, if by this construction this additional annual operating expense could be saved, that is to say, if the line of better alignment, gradients, etc., could be built for an additional cost not exceeding $2,000,000, it would be economy to make this added expenditure for the better line.

It is to be noted in this connection that the calculations for such purposes are, of course, not to be based on the volume of traffic which the road is expected to carry at the date of opening for traffic but for that which may be reasonably expected at some determined future time, say in 10, 15 or 20 years, as the case might be. If, for instance, the road might be expected to have five trains per day at the beginning and ten trains per day in, say, 10 years, then it would usually be reasonable to base the operating cost on a volume of traffic of at least 10 trains per day.

Judgment, of course, must be exercised in determining the volume of traffic to be used in estimating the operating costs, and this is an item of extreme importance and some difficulty in connection with highway work.

This very brief summary necessarily covers only the broad, general features of the theory in a somewhat crude and rudimentary manner. In its application many refinments and minor details must be taken into consideration, and these as they may effect highways are referred to in part hereafter.

Essential Differences Between Railways and Highways.—Wellington pointed out also the need of carefully considering certain other elements which might have to be taken into consideration in determining the final location. Among these may be noted, location of station sites and proximity of the railway to cities and towns, location of terminals, and relations with

other transportation agencies, effect of probable future developments of natural resources, agriculture, timber, mines and of industries, effects on maintenance of a location on one side or another of a valley or elsewhere by reason of differences in exposure, and or in geological formations, liability of snow drifts, etc., etc., all of which in some degree are pertinent to studies of highway locations. In attempting, however, to apply to highway locations economic factors similar to those developed by Mr. Wellington for railroad location, certain essential differences between railways and highways must be borne in mind.

Railways are usually business enterprises operated for profit, or in the hope of profit, by men who are interested in the commercial success of the venture. These men are usually capable of appreciating the work of the engineers who advise them on the costs of making improvements, and who calculate the savings in costs of operation, or set forth the other advantages which are expected to result from these improvements. The results are easily visualized also by figures which are reflected in the balance sheets of the railways at the end of the year. The important fact, however, is that the whole operation, expenditures and resulting savings is in the hands and under the observation of one entity, one group of men with business training, who have a keen appreciation of the value of the dollar and who, as a rule, while spending cautiously and wisely, do not hesitate to spend if they can be assured of a reasonable return on the investment.

In the case of highways there are two important factors which tend to prevent the application of any economic theory of location to its fullest possible extent.

In the first place, it is often quite difficult to convince the people who provide the money for highway improvements of the value of the small savings to the owner or operator of each individual vehicle. The connection is too remote between the taxpayer who pays for the construction and the operator of the vehicle. In the case of a railroad, operating expenses bulk so large that they are subject to the closest scrutiny in every detail. It is the savings of fractions of cents multiplied by the millions of ton miles which make the difference between profit and loss. Very few operators of motor vehicles, moreover, have any real conception of costs of operation. Large trucking companies are beginning to look into and check up these matters, but the average owner knows little, and often cares less, as to what his real operating costs may be or what affects them. The engineer, however, who is an economist—and unless he is an economist he is not really an engineer—should realize what these factors are and plan his work to produce ecomonic results even though he may not be able at all times to convince the public of the economic value of what he does or proposes.

In the second place, unlike a railway which is to be newly constructed, most of our highways have long existed and have grown up with the country, and the country has grown up along the highways. The original trail was widened into the semblance of a road from which the worst obstructions were removed, so that in dry weather it was passable for crude vehicles. Improvements of one kind or another continued, but the location remained more or less that of the original trail and the surface of the road followed quite closely the surface and contours of the ground.

Houses, stores, villages, towns, cities, were established along this route, and not only was its location and alignment pretty well fixed thereby, but also its gradients, because serious or radical changes were too costly for the abuttors, which in most cases meant the community which would have to pay for these changes. It was not only the cost of changing the road at their own expense, but damage to their own property which they had to consider.

Then again, the changes would not soley benefit the owners of the road, that is the abutting property owners or the community, but would benefit also the owners of vehicles who used the road and who might not have to bear any part of the cost of the improvement.

Benefits to Motor Vehicle Owners.—Further, in the early days and even up to very recent times, the actual savings even to the owners of the vehicles were not very apparent. The fact that the time of transit had been lessened, or that the horses did not have to work as hard to pull the load, was not only not very apparent but as a matter of fact did not actually have any calculable readibly value in those days and under the conditions then existing.

Before the advent of the automobile, therefore, it was of very little use for the engineer to ask for money for improvements from people whose properties might quite likely be damaged thereby and who themselves might not get or might no realize any of the resulting benefits, and so the highways have remained fixed in their original locations along the old trails.

With the advent of the motor vehicle, however, the power expenditures of which, under various conditions, may be calculated as is the power expenditures of a locomotive, and when, instead of 15 or 20 vehicles an hour, there may be a thousand or more; conditions have changed, and the change has been especially noticeable since the motor truck and motor bus have reached their present stage of development. Travel is no longer local; it is state-wide and nation-wide.

Moreover, at no time in the history of the world has time been so valuable. It has been truly said that a man today lives through more experiences in one year than our forefathers did in five or ten. To cite a familiar example, as short a time ago as, say 20 years, a salesman could probably only visit one moderate size village or town in a day; today, by reason of the short time involved in traveling by motor between towns, even considerable distances apart, in moving from store to store, or house to house, the automobile permits him to cover two or three times, and often ten times, as much territory in a given time as he could have twenty years ago.

Three General Classes of Streets and Highways.—Without attempting to trace all the various steps which have led to the present state of development of streets and highways in this country, it may be pointed out that these are roughly divided, and I say roughly because all the classes overlap to a considerable extent into three general classes: Municipal streets and certain rural roads for the strictly local use of the individual communities, county roads for inter-communication between these separate municipalities, and the through routes crossing the various states from side to side or end to end and connecting with similar routes in adjacent states, forming a net work of national through highways, these latter being now almost universally designated as state highways.

The problem of main highway construction and location, therefore, is not one for abutting property owners along the route to solve for their own individual needs, but is one to be solved for state-wide and nation-wide travelers. So also the abuttors do not pay for the improvement, but this is paid for by the state or nation at large, and its benefits are state-wide and often nation-wide, leading to state-wide and nation-wide developments.

It is most generally in connection with the construction and improvement of these main highway routes and possibly some county routes that an economic theory of highway location, similar to that used for many years in connection with railway work, is being developed and applied. Many of these highway routes carry a traffic of from 5,000 to 20,000 vehicles per day, and are called upon at times of maximum demand to carry peak loads of 4,000 to 5,000 vehicles per hour. Thus, while the saving to any individual vehicle may be very small per trip, and even not large per vehicle per annum, the aggregate savings per annum to all the vehicles due to improvements in alignment gradient, lessened distance or reduced delays, are considerable volume. In the development of this economic theory, however, the principles of the theory of railway location above referred to have to be modified in their application though the principles themselves remain the same.

Component Items of Cost of Motor Vehicle Operation.—First, it is necessary to divide the cost of operation of

motor vehicles into its component items, which for our present purpose may be assumed to be the following:

Interest on capital invested.
Allowance for depreciation.
Insurance—fire, accident and liability.
Driver's wages.
License fees.
Gasoline and oil.
Maintenance and repairs; tires, garage, washing, etc.
Overhead (if tuck or bus is one of a fleet).

It is, of course, apparent that some of these items are sources of expense whether the vehicle be running or standing still. It will also be realized that they vary for each type of car, truck or bus and with the type of pavement. The cost of power for the operation of the same vehicle and load on a dirt road will evidently be geater than it will be on a smooth, hard pavement, and there will be greater wear and tear on the machine. Costs of operation will therefore vary with the type of pavement and vary in different sections of the country, depending on costs of labor and prices of oil, gasoline, etc. It is probable, however, that for most purposes of the application of this theory to almost any location it can be assumed for purposes of comparison that the operating costs are those for vehicles running on modern smooth pavements. The comparison can usually be on this basis, even though the road might in the first instance be a dirt or gravel road, and, as previously stated, this theory is most generally applicable to the design of location of important through routes.

It is to be further noted that differences in location affect some items of operating cost for all cars passing over the route; others are only effective during what may be called the rush hours, when the road is being used to capacity.

Economic Effect of Distance.—The consideration of the economic effect of distance, or differences in length of route, may be divided into two parts—first, the effect of short distances, which only affect wear and tear of the vehicle, and consumption of gas and oil; and, secondly, distances which affect drivers' wages and limit the uses of commercial vehicles.

The consideration of the first is a comparatively simple matter. It is easy (assuming that proper data are available) to ascertain the costs of the items directly resulting from the movement of the vehicle, which are:

Fuel and lubricants.
Tires.
Repairs or maintenance.

It is further a simple matter to determine the cost of these items per mile or per foot for any given vehicle, and if all the vehicles using the road were alike it would then be only an easy step further to ascertain the effect of a given distance on the costs of operation of these vehicles.

The vehicles using any given road vary widely in character, however, and it is not possible, of course, to determine exactly the proportion of each of the various types, but generally a reasonable estimate can be made and, given the number of each, the cost of operation per mile or per foot for the items referred to for the number of each class, can be obtained or estimated.

From this it can be ascertained how much can profitably be spent to shorten the line by a given number of feet, or if a shorter, more expensive line be compared with a longer one, how much additional money can profitably be spent to obtain the shorter line.

There have, then, to be considered distances which appreciably affect the time of the vehicles passing over them.

A vehicle traveling at the rate of 15 miles per hour will pass over a mile in four minutes. For ordinary passenger cars and for distances up to a mile or two, time can therefore hardly be considered an item of appreciable cost, nor will it be ordinarily in the case of a truck.

Should the distance be increased, however, to the extent that it would, for instance, affect the number of trips a truck might make in a day, or require payment to the drivers for overtime, this would have to be taken into account and a proportion of the other items of interest, depreciation, insurance, etc., be included in the extra expense caused by additional distance.

Ordinarily, as traffic is conducted today, it is probable that for all distances up to, say, roughly, two miles, the only items, affected are those first referred to, namely, fuel, lubricants, tires, and repairs.

Effect of Curvature.—It is entirely probable that curvature of the kind used on railroads has no effect of importance on the cost of operation of motor vehicles.

Curves of 1,000 ft. or larger radius will have little effect on slowing up speed, and the additional wear and tear on the running gear or additional power required for turning is so small that it is probably negligible. At any rate, we have as yet no data available in regard to it.

Roads with a succession of sharp curves, sharp right angle turns, or curves of very small radius, say any radius less than 200 ft., not only tend to slow up speed, but also introduce elements of danger.

The effect of the lessened degree of speed can be estimated by determining its relation to the normal average speed of vehicles under normal conditions of visibility, etc., on the same road.

If, for instance, the normal speed can be assumed to be 35 miles per hour and a curve or succession of curves causes this to be lessened to 20 miles per hour this would have two effects: One to lessen the capacity of the road to carry traffic, and, second, loss of time to the vehicles and their users.

The first of these would only be effective if the road were being used to capacity and then only during such periods as such demand occurred, and the second would, of course, apply to all vehicles. There is also the element of danger which should have careful consideration.

Rise and Fall.—Two elements have to be considered in connection with rise and fall—the height to be overcome and the rate of gradient. The two, however, must not be confused. Taking a profile of a railway or highway, rise and fall is half the sum of the difference in elevation on both ascending and descending gradients between two given points or termini. Suppose, for instance, starting from "A" there is a rise of 80 ft., a drop of 60 ft., a rise of 30 ft., a drop of 50 ft., the sum of these, 80 plus 60 plus 30 plus 50, is 220 ft., and the rise and fall of the line is said to be 110 ft.

The value of both rise and fall and rate of gradient are affected in a marked degree by the kind of pavement and type of vehicle.

A rate of gradient which requires shifting of gears evidently has a greater effect in increasing operating expenses than one which can be negotiated in high, and this rate, as is self-evident, is markedly affected by the type of pavement.

Rise and fall over small elevations or for short distances or on low rates of gradient, probably has little effect on operating costs. Little has been done, however, in the way of experiment or tests to determine just what the limits are.

Speaking generally, it may be stated that the principal item of expense which rise and fall affects is consumption of power. Distance and alignment being the same, the additional power required is that necessary to raise the vehicle and its load to the given height.

The Cost of Delays.—An item of operating cost which Wellington did not take into consideration in connection with railroad location was that due to delays. In the operation of modern railroads, however, it often has to be considered. Generally speaking, on railroads, delays are due to waiting on side tracks for the passage of other trains, the locomotive in the meantime burning coal at a loss, the train crew losing time, and the tracks being occupied an undue length of time.

In the case of highways, delays occur mostly at intersections with cross streets, at grade crossings of railroads, and at open drawbridges over navigable waterways.

Ordinarily such delays only cause a loss of time to the owners or operators of the vehicles and of fuel consumed while the engine is running idly during the stop.

In the case of congested highways, however, such delays have a much more important effect, inasmuch as they de-

crease the capacity of the highway to carry traffic.

Suppose, for instance, that during certain hours of the day 1,500 vehicles per hour desire to pass over a given highway.

Suppose, further, that if this highway were free from intersections with other roads and the traffic could proceed without interruption, the 1,500 vehicles per hour could pass over it comfortably.

Now suppose further that by reason of interruptions and delays not more than 1,000 vehicles per hour could get over this road.

It is evident, then, that other routes would have to be provided to take care of the balance of the traffic, thus requiring a further investment of money.

The economic problem, then, is whether it is cheaper or more practical, or more desirable, to build an additional route or to remove the obstruction from the first.

This problem evidently will occur only on roads which carry a heavy traffic, but these are becoming more and more numerous, and as they do, the need of properly solving this problem will be more and more apparent.

There is also, of course, besides the loss of time, expenditure of fuel while waiting, and decreased traffic capacity of the highway, the element of danger at railroad crossings and at crossing with other highways, especially where there are no signals and vision is obscured.

It is, of course, impractical in a paper such as this to go into much detail to show how actual monetary values are arrived at, but to help a better visualization of the subject, some of the figures showing costs of delays are given, which were developed in the investigation of the location of the road first referred to, that is, the Arterial Highway being built by the State of New Jersey through the congested metropolitan area adjacent to New York.

The value or cost of a car minute was first determined for different average types of motor vehicles, that is to say,

For trucks—2.3 ct. per minute.

For passenger cars (busses)—2.1 ct. per minute.

For pleasure cars—1.0 ct. per minute.

In order to establish the average value of one car per minute, it was then, of course, necessary to determine the number of vehicles of each type which might be expected to use the highway.

It was expected that the proposed highway would be used mostly for trucking purposes. With a preponderance of trucks, passenger cars will more and more avoid the route, so that in time few if any, passenger cars will use it. In order to provide a basis of computation, it was assumed that 75 per cent of the vehicles would be trucks, 20 per cent passenger cars used for commercial purposes and 5 per cent pleasure cars. Taking these proportions and applying the values per minute as deduced, there was obtained an average value of

2.2 ct. per car minute.

In applying this to an examination of the loss at a single grade crossing of the main highway carrying four lines of traffic, averaging 20,000,000 vehicles a year, with an intersecting main highway, it was found that, counting only the delays at times of maximum traffic, when traffic is actually stopped and held up by signal, it was found that for the traffic assumed, the loss was 7,000,000 car minutes a year; that is, $154,000 per annum. Assuming therefore, that money can be obtained at 4 per cent per annum, it would be economically sound to spend $3,850,000 to eliminate this delay.

In addition to this actual loss to the operators of vehicles, there is, of course, also the loss due to the decreased capacity of the highway for handling traffic, which in many instances amounts to very large sums of money. In other words, by increasing the capacity of one route by removing obstructions, the time is postponed when expenditures for opening or improving another route become necessary.

The above covers in a very general way and in barest outline the general features of the application of the Economic Theory to the main physical features of Highway Location. In order to indicate the methods used in working out the details, the following is given as an example of the methods used in arriving at values of distance for the Arterial Highway previously referred to.

Cost of Operating Trucks.—First, there is the method of determining the costs of operation for different types of vehicles which are affected by distance, the following figures compiled from various sources representing approximately the cost of operating a 3-ton truck in the vicinity of New York:

	Cost per Time	Annum Mileage
Interest on $3,600 at 6 per cent	$ 216	
Depreciation		$ 720
Insurance	300	
Driver's wages, 300 days at $5.60	1,680	
License fee	25	
Gasoline, 6 miles per gallon, at 25c.		500
Oil		75
Tires		270
Repairs and Maintenance		360
Miscellaneous		200
Supervision and garage	200	
	$2,421	$2,125

Assuming that the total mileage per annum is 12,000 miles, the costs directly chargeable to distance are 17.7 ct. per mile.

The cost of operation of a 2½-ton motor truck, compiled by the engineers of the New York Port Authority (1924) were as follows:

	Cost per Time	Annum Mileage
Garage	$ 242	
Gasoline		$ 412
Oil, grease, etc.		412
Repairs, labor, parts, tires		969
Chauffeur	1,482	
License	20	
Insurance	26	
Interest, $2,000 at 6 per cent	120	
Depreciation, ⅓ of $2,000	667	
	$2,557	$1,488

The above is based on a mileage of 12,000 miles per annum, gasoline 10 miles per gallon at 33 ct. per gallon, and shows costs directly chargeable to distance of 12.4 ct. per mile.

The above figures indicate a rather low cost per mile, this being due to the assumed mileage per gallon of gasoline being rather high.

From these and other similar figures, cost of operation due only to distance of 15 ct. per mile was arrived at for the purpose we then had in mind. It will, however, be realized that these values may vary very considerably for other purposes and other conditions, all of which must be considered for each individual case.

In a similar way, operating costs affected by distance were determined to be, in the case of light trucks and busses, 10 ct. per mile; for passenger cars, 6 ct., and for the assumed proportions of each, 11½ ct. per mile.

Now, assuming that a given highway is to be used by, say 2,000,000 vehicles per annum, the saving of a mile in distance means an annual saving to the owners of these vehicles of

$2{,}000{,}000 \times 11.5 \text{ ct.} = \$230{,}000$ per year

and again, if money can be obtained at 4 per cent per annum, that some $5,750,000 might be spent to reduce the length by a mile, and proportionately, of course, for other distances which affect only these items of operating cost.

Of course, it will be remembered that there is hardly any case where it is feasible or practical to save a mile of distance and not materially affect other elements, property and commercial interests, and many other things to which reference has been previously made, and here also may be noted the effect of traffic estimates. If the estimated traffic be half as much or any other number, or if the class and character of the vehicles be changed, then the amount which may be spent to reduce a given distance is changed in proportion.

Main Division of Economic Theory of Highway Location.—Without going further into details, therefore, which it does not seem practical to do within the scope and limits of such a paper as this, the consideration of this economic theory of highway location may be summed up and divided into the following two main divisions:

First. The consideration of what may be called the political and social aspects. The location of the highway to best serve the inhabitants of the

adjacent territory and the general users of it.

Secondly. The adjustment of costs of construction to the costs of operation of the vehicles which travel over it.

There is to be considered with these the question of economy of construction, the effect of location and details of construction or maintenance, and the relation of cost of different types of pavement to their useful life and suitability to the traffic which will use them.

Perhaps also a further word of caution may be said in closing. The application of this theory to highway location can as yet be based only on a rather imperfect knowledge of all the governing factors. It must, therefore, be applied only with a great deal of discrimination and by engineers of ripe experience and good judgment. The speaker, however, believes that it should be much more generally used and studied than it is and used as a guide and check on the judgment of even the most experienced of engineers.

Even with all its imperfections, however, it can be used even to-day to demonstrate the comparative values of two or more proposed locations over which it is proposed to pass the same volume and character of traffic. Within practical limits the errors of assumption, being the same in both cases, will not affect the comparison, and it is the duty of the engineer charged with large expenditure for important improvements to use this check on his judgment.

Paraffin Solution Used on Molds for Cement Mortar Briquettes

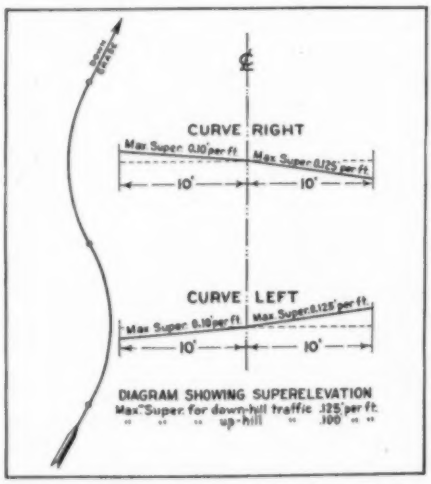
Paraffin solution has been found to be much better than oil for preventing cement mortar from adhering to briquette molds, glass plates, or any other laboratory apparatus, according to R. B. Dayton, materials engineer of the State Road Commission of West Virginia.

A 6 to 7 per cent solution of paraffin in carbon tetrachloride is used instead of the customary heavy mineral oil. It may be applied with either a brush or rag. The surfaces of the molds are very easy to clean, requiring but slight brushing with a stiff fiber brush. The top and bottom of briquette molds require a slight scraping with a small trowel to remove the mortar, as the process of forming removes the paraffin coating, but this also happens when oil is used.

One advantage of the paraffin solution over oil is that the paraffin solution is quick drying and does not become incorporated with the mortar as sometimes happens with excess oil on the molds and plates.

Each Half of Pavement Has Different Superelevation

Some unusual construction features were embodied in the Mountain Springs grade paving project completed last June by the California Highway Commission. The new highway, 6.8 miles in length, extends from the Myers Creek bridge in Imperial County to the top of Mountain Springs grade in San Diego County.

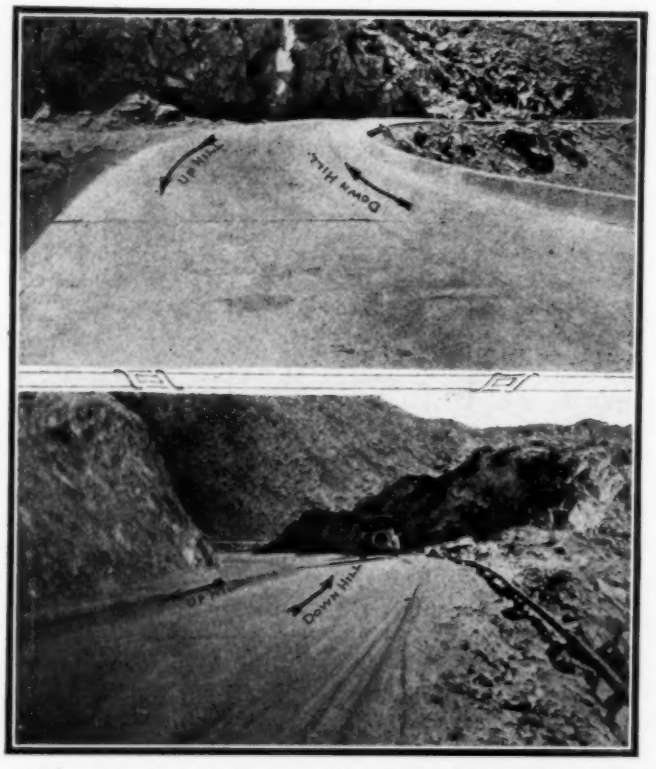


Plan for Mountain Springs Grade Paving Showing Variation in Super-Elevations at Center of Paving

Superelevation.—Owing to maximum grades of 7.12 per cent, and curves with radii as sharp as 140 ft., the matter of superelevation was given considerable study. Much of the traffic over this road is heavy trucking from Imperial Valley to San Diego, with slow up-hill and fast down-hill speed, and to care for this condition a compromise superelevation was adopted. Each half of the pavement was designed with different superelevations suitable for the unusual difference of speed. Had the maximum superelevation been used of 2½ ft. in the full 20-ft. width, there would have been danger of the heavy trucks with high loads over-turning or sliding to the low side of the pavement.

According to California Highways, the results obtained in the riding qualities of the finished pavement justify the type of construction adopted. In spite of the steep grades and sharp curves motorists can drive with safety in either traffic lane.

Another feature worked out successfully in this job is a combination curb and guard rail. By thickening the curb and constructing it a few inches higher than the customary standard it served both purposes.



Two Views of Completed Mountain Springs Grade Paving Which Show Change in Angle of Super-Elevation at Center of Roadway

The Jahn & Bressi Construction Company, Inc., were the contractors, and began work in February, 1927. The paving is of Portland cement concrete, 20 ft. wide, laid in two 10-ft. strips, each 6 in. thick at the center and 9 in. at the edges. Considerable drilling and blasting was done ahead of the subgrade shaping, to widen the roadway and improve the alignment. Making subgrade in the rock was very expensive, and the total cost of the job was $416,255.

An Important Cost Item

How to Figure Wear on Equipment; Depreciation and Obsolescence

By A. H. HUNTER

Field Engineer of Illinois Association of Highway and Municipal Contractors

Equipment and its use on highway and municipal work presents a problem in cost records and estimating that has not yet been thoroughly understood by the contracting profession. The useful life of most construction equipment extends over a period of several years. Were its usefulness or utility consumed within the limits of a construction season, or a year at the most, an expense charge covering the entire first cost could be entered in the books and would be understood by all. Unfortunately the computations for depreciation or actual wear and tear on equipment are not so simple. The useful life of construction machinery normally will extend over a period of several years; its use will be varied and unavoidable periods of inactivity will result in difficult adjustments. This failure to understand depreciation or to comprehend the problem, even in part, undoubtedly has been accountable for more variation in bid prices than all other elements entering into the cost of construction.

Small wonder that such confusion has occurred in the past. Without stability in requirements for completed streets or highways, how can we hope to have stability in mechanical equipment necessary to produce that product? Only in the last few years have we seen an effort at standardization of specifications such as give some assurance that changes would not occur to make obsolete or unserviceable equipment on hand.

In the earlier years of highway work, labor comprised an appreciable item of construction cost. From year to year we found a gradual advance in mechanical development until in recent years equipment has supplanted labor to a large extent.

This change was most marked during the war. The scarcity of labor during war time brought about a search for suitable equipment as a substitute. With this change came added confusion in cost systems, with new items of depreciation, repairs, fuel, oil, and gas.

On the basis of present-day equipment a paving outfit complete to handle adequately all construction work will involve an investment of $75,000 to $80,000. This should be understood as applying only to highway surfacing problems. In the case of bridge construction or earth grading still other additions will be required to provide the equipment necessary. This estimated investment of seventy or eighty thousand dollars is based on conditions as now found in the construction field. In a measure we are inclined to approximate conditions in the future by the past, although there seems some likelihood that contractors may in the future be inclined to limit their activities to smaller sections of work and by so doing attempt to reduce or keep within lesser limits their expenditures for equipment.

The need for immediate improvement of many of our main highways has convinced the engineers of the necessity of limiting the time of completion on paving work. It is no longer possible for a contractor to obtain work which he cannot complete during one construction season. In other words, it is not possible for a contractor to estimate in advance the volume of his work for a period greater than one year. At the end of that year his equipment would still be serviceable and have construction value. He must make an effort to approximate the conditions that will be encountered in the industry for at least three or four seasons in advance. Changes in general business conditions together with the amount of available work has a very important bearing on the situation.

In further explanation of this problem let us recall the construction seasons of highway work in Illinois. In the years 1923-24 completed work exceeded 1,000 miles per season. The completed mileage in 1925 was almost as great. In 1926 the volume of available work was reduced to almost half that of former years and the outlook for 1927 is such that we are reasonably safe in predicting that the miles of completed highways can be only a fraction of the work completed in former years. It readily will be seen that this has an important bearing upon prices and in a measure upon the problems involved in equipment.

Let us consider the equipment problem in its entirety, and endeavor to take all the cost incidental to equipment, its use, care and transportation, and incorporate them in one item of cost. In brief, this will include such items as depreciation, repairs, fuel, gas, oil and grease, freight to and from the job, storage and care of machinery, and rent. This last item may not always be present, but most contractors are inclined to rent special equipment from time to time. In a measure rent is a substitute for investment in equipment.

Depreciation in highway equipment is an attempt by the contractor to evaluate in dollars and cents the effects of time and service upon the physical properties of his equipment. Do not expect to reach a definite solution. Variation in the manufacture of the equipment, its use and the nature of the work, maintenance, improper storage and the personal attitude of the contractor himself have much to do with the rate at which these physical properties are impaired. Also, changes in types of highways, revision of specifications or unexpected industrial advance may suddenly end the value of construction equipment and upset the most complete depreciation calculations. In other words these many possibilities suggest that the contractor must be on the alert and by various means assure himself that the depreciation method employed is sound and has adequately met the demands of the problem at hand.

Two thoughts are deduced from the foregoing which should be considered seriously before going further:

First: Depreciation is strictly a measure of the service rendered by the equipment.

Second: The element of time, irrespective of the service or use of equipment, will affect its usefulness and value. This effect of time is spoken of ordinarily as obsolescence. The importance of obsolescence and its effect upon the useful life of property is too often neglected.

We will endeavor to express what, in our judgment, are reasonable limits between which depreciation must be figured by the contractor if financial loss is to be avoided. We might make one assumption—that of a season's work only. Inasmuch as a contractor now is unable to take on more than a season's work at a time he might, after completion of his contract, sell his equipment and charge to depreciation the difference between first cost and selling price. Such an arrangement is permissible under the policies of the Federal Income Tax bureau.

A second assumption—that of five full seasons of work. At the end of this period the equipment would be worn out and depreciation could have been distributed on the basis of 20 per cent per year. These limits are only a suggestion and it is believed that the rational place is somewhere between the figures mentioned. The first assumption is financially sound, but suggests no particular merit to one permanently engaged in a business. The second assumption is reasonably workable, but is positively unsound for the reason that no man can predict the volume of available work or the serviceability of his equipment over so long a period.

It is our opinion that depreciation should be spread over a three or four year period. We are inclined to believe that the rate of depreciation in the

earlier years of this period should be greater than the normal flat rate or a straight line arrangement. This suggestion pemits some reasonable leeway in working out the balance in subsequent years. Even enforced idleness for one year would not make impossible the liquidation of an equitable amount.

Following is a brief discussion of several methods that have been in common practice in the construction industries and which have received favorable comment from the United States Chamber of Commerce, Federal Income Tax bureau and others.

FIRST: The old straight line method of depreciation consists of estimating the useful life of each piece of equipment in years, and charging off a uniform portion of the initial cost during each year of the estimated useful life. That is, if a piece of equipment will last four years, one quarter of its cost, or 25 per cent, is charged to depreciation each year whether the equipment is in use or is idle.

SECOND: The unit of work method of depreciation consists of estimating the units of work which a piece of equipment will do before it becomes useless through wear or for other cause, then dividing the initial cost of the equipment by this number of units of work to find the cost of equipment consumed in doing one unit of work. These units may be tons, cubic yards, hours or any other suitable unit of measure. Thus, if a concrete mixer will do twenty miles of paving work before it is worn out, one-twentieth, or 5 per cent, of its initial cost is charged to depreciation for each mile of paving construction which it does. With this method depreciation is not charged on idle equipment, but is charged on all equipment in use; that is depreciation is charged for income producing equipment, but not for non-income producing equipment.

THIRD: The job basis of depreciation consists in charging the difference between first cost of a piece of equipment and its actual or estimated saleable value at the end of the job against the job for which the equipment was purchased. This method applies to special equipment purchased for a particular job, and for which no further use can be predicted definitely when the job for which it was purchased has been completed. The method also applies to contractors who make a practice of selling all equipment at the completion of each job and buying new equipment for the next contract.

FOURTH: Composite rates of depreciation are determined by listing entire equipment with cost and item rates of depreciation (either straight line or unit of work item rates) and then determining an average rate for the entire equipment by dividing the total of the item amounts of depreciation by total cost of equipment. When a composite rate of depreciation is used there will be no charge to profit or loss when items of equipment become useless or obsolete, or otherwise are abandoned. The average rate is supposed to provide for all such contingencies and if one item does not last as long as estimated it is presumed that some other item will be useful for a longer time than was estimated, and the loss on one will be balanced by over-depreciation charges of the other.

The property account includes all items still in use at initial cost. When an item is disposed of its initial cost is taken out of the property account and the initial cost, less actual salvage value, also is taken out of the depreciation reserve. That is, it is assumed that the depreciation reserve contains the full amount of actual depreciation on the item. As an illustration, assume that there are two items of equal value, each having an estimated life of five years, and 20 per cent depreciation on each is included in the average or composite rate. One item is scrapped at the end of four years and the other at the end of six years. No loss is written off for the four years item, but the composite rate of depreciation allows 20 per cent for six years, or a depreciation of 120 per cent of the cost of the six-year item.

FIFTH: The job basis can be used for special equipment and if this equipment is not sold but is retained by the contractor for use in possible future jobs, the balance of its cost may be depreciated either over the estimated remaining years of useful life or over the estimated remaining numbr of units of work of which the equipment is capable. Perhaps this can be explained better by definite example, for instance: Purchase a new mixer at $8,000 and figure that it has a useful life, that is life to the contractor where it is an asset and not a liability, of 20 miles of pavement. This machine is purchased to go on an eight-mile section the first season, knowing that upon the completion of these eight miles it will have a market value of not more than 50 per cent of its initial cost. Its depreciation is figured at 50 per cent on its initial year. Take eight miles out of its expected 20 miles of useful service, leaving 50 per cent that may be depreciated on a unit basis over its other 12 miles of expected useful life. This may be taken ous in one, two or three years as available work is obtained for the mixer. An allowance also may be made for storage whether the machine is under cover or in the open, it being conceded that a machine in open storage will depreciate practically as rapidly as it will in operation.

In our opinion the problem of arranging adequate returns on investment in equipment is so poorly understood or provided for that it represents a large portion of the loss now occurring in the construction industry. Uniform rates of depreciation for the entire industry should be established, and to this end the Associated General Contractors have appointed a committee to confer with members of the treasury department of the federal government where an effort is being made to stabilize the problem of depreciation for income tax purposes. In brief, this study of depreciation is an effort to establish some common practice based on sound business principles that will be applicable alike to cost accounting and federal income tax.

May we suggest a word of caution as to the limits of construction work upon which contractors might base their depreciation? Too frequently volumes of production have been assumed that far exceeded the available amount of work. Some few weeks ago we took the time to peruse construction records of the Illinois Division of Highways pertaining to the volume of work completed in the past several years. A tabulation follows, showing the amount of work built each year, the number of mixers employed and the average miles produced per mixer.

Year	Miles Built	No. Mixers	Miles per Mixer
1920	340.6	126	2.70
1921	413.9	102	4.06
1922	740.8	213	3.48
1923	1,085.0	199	5.45
1924	1,229.5	183	6.72
1925	906.4	130	6.97
1926	463.7	104	4.46

A casual glance at these figures will indicate that under average conditions and during the best seasons the miles of standard 18-foot concrete highways completed in the state did not exceed seven miles per mixer.

No doubt many of these mixers employed on state work or county aid, which is included in this tabulation, did an appreciable mileage of outside work. We very much doubt if it were possible to account for this feature of added work if the average production per mixer would exceed eight miles per year. In the past many contractors have assumed unreasonable mileage as possible for their equipment, neglecting to bear in mind that adequate construction programs may not always be available. The capacity of the modern mixer may be fifteen miles or more per season, but the amount of work built on an average will be governed by the number of miles of work available.—Public Construction News.

French Roads Said to Be in Bad Condition

France's once famous roads again are in a deplorable state, in the opinion of Charles Faroux, a leader among automobile engineers and touring authorities.

Faroux has called upon Andre Tardieu, minister of public works, for an explanation, declaring that parts of the 40,000 kilometer system of main highways are almost bogs and that hundreds of kilometers are barely passable.

Besides this main system of hard roads France has more than 500,000 kilometers of small roads and lanes, but it has been the government's policy to see that the chief arteries are in good condition.

Protection of Concrete Against Alkali

Methods and Costs of Treating Structures with Tars Given in Public Roads

By E. C. E. LORD

Petrographer, U. S. Bureau of Public Roads

Numerous structures exposed to the action of alkali of sea water have been successfully treated both above and below water line. As a typical example of under-water treatment may be cited the case of a bridge pier in Cowley County, Kans., reported by T. J. Lough, materials engineer, Bureau of Public Roads, District No. 5. The schedule of treatment as compiled from Mr. Lough's report is given in Table I.

Table I—Schedule of Treatment of Bridge Over Arkansas River, Kansas

Date 1926	Treatment	Time required for application Hours	Number of men required for application	Man-hours per 100 sq. ft. H.m.	Time allowed for drying Hours	Tar applied on 49.5 sq. yd. Gallons	Rate of application per square yard Gallon
June 28	Cofferdam unwatered	..	.....	.....	51	.....	.....
June 30	First coat water-gas tar	2½	1	0:34	3½	4.8	0.097
June 30	Second coat water-gas tar	1¼	2	0:34	13¾	3.0	.060
July 1	Third coat water-gas tar	1¼	2	0:34	8	2.2	.044
July 2	Fourth coat water-gas tar	1¼	1	0:17	13 5/6	1.6	.032
July 3	One coat coal tar	1 1/6	2	0:31	24	2.24	.045
Total	Five coats	7 5/12	..	2:30	114 1/12	13.84	(*)

*Water-gas tar 0.233 gal., coal tar 0.045 gal.

Purpose of Treatment.—The purpose of the treatment was to protect the concrete from the action of alkali water of the Arkansas River. (See Fig. 1.) The treatment consisted in applying successive coats of water-gas tar and one coat of coal tar to pier No. 1 of the bridge 2.75 ft. above and below water level, the treated band having an area of 49.5 sq. yd.

It was carried out under very favorable weather conditions, temperature ranging from 68° to 96° F. and a bright sun and light breeze persisting throughout the days of treatment.

The concrete was fabricated of one part cement, two parts of fine Arkansas River sand, and approximately three and one-half parts of clean, washed flint gravel, and was two months old when treated.

Pumping Units.—Two pumping units were employed to unwater the cofferdam. This was to preclude the possibility of water reaching the concrete under treatment should one pump break down. No difficulty was experienced in holding the cofferdam dry.

Condition of Concrete.—At the time of applying the initial coat of water-gas tar the concrete appeared to be dry and in a satisfactory condition to receive the tar. The concrete was wire-brushed immediately prior to the application to remove a film of water-deposited impurities.

Rate of Absorption.—Where exposed to the sun's rays and the breeze the initial coat penetrated rapidly. On shaded areas the absorption proceeded more slowly. The penetration was not uniform, indicating variations in the density of the concrete. On the web of the pier, the concrete of which had received the most spading, absorption proceeded at the slowest rate.

A decreasing rate of absorption of the successive coats was noted, requiring increasing time intervals between the successive applications. The priming coat had been fully absorbed when the second coat was applied. Small areas had not been fully penetrated when the third coat was applied and slightly larger areas had not been completely penetrated at the time of placing the fourth coat. Considerable areas of the fourth coat were sticky and not entirely absorbed when the coal-tar seal coat was applied, indicating that the saturation point was approached. Postponement of the seal coat application to permit possible additional penetration of the water-gas tar was considered unwarranted.

Application.—No difficulty was experienced in applying the tars with ordinary calcimine brushes. The seal coat was spread out as thin as practicable and was applied cold, heating not being necessary. The proximity of the cofferdam to the concrete with resultant restricted working space somewhat handicapped the workmen in applying the tar, but a workman of average ability should be able to apply a coat of either kind of tar at the rate of 25 sq. yd. per hour.

Penetration.—Immediately prior to the application of the seal coat a number of holes were drilled through the water-gas tar coats and the depth of penetration was found to average one-eighth inch.

Cost.—The cost of the entire operation was as follows: (1) Moving pumps, $15.83; (2) pumping, $177.94: (3) cleaning surface, $5.35; (4) cost of tars, $5.60; (5) applying tars, $10.81; total, $215.53, or $0.484 per square foot of surface.

Summary and Conclusions.—The following conclusions may be considered as applying to treatment under conditions similar to those described:

1. Duplicate pumping units are essential.

2. Given favorable weather a 48-hour initial drying period for the concrete is sufficient.

Fig. 1—Application of Tar to Pier of Arkansas River Bridge, Cowley County, Kansas

3. Rate of absorption is affected both by density of concrete and exposure to sun and wind.

4. As each coat of water-gas tar is less rapidly absorbed than the preceding one, the time intervals between applications should be correspondingly increased, so far as the working day and a reasonable total period of treatment will permit.

5. A workman of average ability should be able to apply a coat of either kind of tar at the rate of 25 sq. yd. per hour.

6. Approximately 2.5 gal. of water-gas tar per 100 sq. ft. of surface are required for four applications; and one application of coal tar in the amount of 0.50 gal. per 100 sq. ft.

7. The average penetration of the water-gas tar at the time of applying the seal coat will be approximately one-eighth inch.

8. Absorption of more than four

coats of water-gas tar is not obtainable without extending the treating period.

9. The concrete must be held in the dry for five days to permit satisfactory treatment.

10. The efficacy of the treatment can only be determined after a considerable lapse of time, and then only by comparing the condition of untreated concrete masonry exposed to the same stream.

Other structures receiving the tar treatment have been reported as follows:

Abutments and Piers of Bridge Over the Arkansas River Near Ford, Kansas (F. A. P. No. 236—A. Dist. No. 5).—The area treated was 2,489 sq. ft. on two abutments and six piers, 3 ft. above and 3 ft. below low water line. After unwatering the cofferdam the masonry was allowed to dry out for four or five days and the area to be treated was thoroughly cleaned with a stiff wire brush. The treatment consisted of six coats of water-gas tar and one coat of coal tar conforming to the provisional specifications of the Bureau of Public Roads. A coat of water-gas tar was applied by going completely around the pier or abutment and ending at the point of beginning. At the completion of the first coat the tar that had first been applied was dry enough to receive the second coat. About two hours elapsed between the application of the second and third coats. The third coat was allowed to dry for four or five hours before placing the fourth coat. After drying out over night the fifth coat was applied and in the afternoon of the second day the sixth coat was put on.

The seal coat of coal tar was usually placed later in the afternoon of the second day, a swab being used instead of the brush used to apply the water-gas tar. It was found that two men could finish a pier or abutment in two days.

The rate of application was about ⅛-gal. of water-gas tar per square yard of surface and slightly over 1/10 gal. of coal tar. The approximate cost of treatment, including pumping, labor, fuel, oil and tars was $540, or about 22 ct. per square foot.

Coast Highway Bridge Over North Channel, Santa Maria River, About 2 Miles North of Santa Maria, San Luis Obispo County, Cal. (F. A. P. 25—C).—The treatment of piles supporting the bridge girders consisted of two coats of water-gas tar applied before driving and two additional coats after driving covering the exposed portion and extending two feet below the normal ground line. The bed of the stream was dry and there was no difficulty in excavating around the piles to a depth of two feet. The application was made with calcimine brushes. A stream of tar from the spout of a watering pot was run along the top surface of the pile as it lay on one of its sides and this was brushed into the top and sides, giving an especially thick coating on the top. The pile was later turned through 180° and the fourth side was treated, as well as the two vertical sides where additional tar could be absorbed. The piles had dried out after curing for more than a month, so the tar absorption was rapid. The tar was used at a rate of 1⅛ gal. per 100 sq. ft. The depth of penetration was about ⅛ in., or as much as might be expected from three or four applications within a few days.

Reinforced Concrete Viaduct Between Wilmington and Long Beach, Cal., Over Part of the West Basin of Los Angeles Harbor.—The treatment was here given to concrete footings and extended from the ground surface to two feet below permanent low water level. It consisted in applying about six coats of water-gas tar followed by a seal coat of coal-tar pitch, at a cost, including labor, of 43 ct. per 100 sq. ft. for the water-gas tar and 96 ct. for the coal tar. The concrete was a 1:3:5 mix, and although the penetration of the tar did not exceed ⅛ in. it was felt that an excellent waterproof condition had been obtained.

St. Marys River Bridge, Camden-Nassau Counties, Fla.-Ga. (F. A. P. 421).—The parts treated were the backs of abutments from top of footing to top of embankment, the faces of abutments from top of footing to an elevation 3 ft. above high tide, the reinforced piers from top of footing to 3 ft. above high tide, the under sides of slabs and girders and the sides of girders of the concrete approaches unexposed to view.

The treatment consisted of ten coats of water-gas tar (grade TW-1-X) uniformly applied with a brush in ten separate applications at intervals of 2 hours each, the first application being made immediately upon the removal of the forms, or as soon thereafter as the concrete became sufficiently dry to receive and hold it.

Morehead City-Beaufort Bridge, Carteret County, N. C. (F. A. P. 64—A Reo.).—The treatment consisted of four coats of water-gas tar and one seal coat of coal tar on bascule pier shafts and concrete piles.

The concrete of the four pier shafts consisted of one part cement, two parts of clean bank sand and four parts of washed flint gravel, graded ¼ to 1½ in. The piles were fabricated of one part cement, one and one-half parts sand and three parts gravel, graded ¼ to ¾ in. in size.

The treatment of the shafts extended from 6 ft. above to 6 ft. below mean water level. The tars were applied very effectively with calcimine brushes with very long handles, as the cofferdams were too close to the shafts to permit free working conditions around the pier.

The concrete was dry and clean when the tar was applied, and the rate of absorption was reasonably uniform except where the concrete had taken up resin from the boards. These places stood out prominently and the absorption was very slow.

Each successive coat showed decreasing absorption and thus required longer intervals between applications, but in no case was the time required for the penetration of a coat more than one hour and 15 minutes. Small areas were not completely dry when the fourth and fifth coats were applied.

Under conditions similar to the above one man should apply 270 sq. ft. per hour of the first coat, 315 sq. ft. per hour of the second, third and fourth coats, and 210 sq. ft. per hour of the seal coat. The quantity of tar used on this project per 100 sq. ft. of surface was 2.95 gal. of water-gas tar and 1.10 gal. of coal tar. The method of treatment appears satisfactory and is recommended.

The treatment of the piles extended from 2 ft. below mean low water to 1 ft. from the end of the pile, the treated length varying from 6 to 16 ft. The pile was always dry when painting was started and was allowed to dry thoroughly after each successive coat. The painting was done with ordinary calcimine brushes and a penetration of from ⅛ to ¼ in. was obtained.

The cost of painting the piles, if so stored that they are accessible, is very small. It would be advisable to arrange the storage so that as few piles as possible have to be moved for painting, by so spacing them that they can be reached on all sides for treatment.

The length of time between the application of the seal coat and driving should be not less than seven days.

Cheat Haven Dam, Cheat Haven, Pa.—This treatment, reported by H. H. Haggard, of Sanderson & Porter, Engineers, New York, was applied to the upstream face of the dam and to the interior of penstocks and scroll cases. Approximately 7,000 sq. yd. of the dam face was given two coats of water-gas tar at the rate of about 0.285 gal. per square yard, followed by one coat of coal tar at a cost for both applications of about 30 ct. per square yard. The work was all submerged in December, 1925, and has not since been exposed for observation.

The penstocks and scroll cases received two coats of water-gas and two coats of coal tar. The two coats of coal tar proved to be too heavy and showed a tendency to run before water was admitted to the penstocks. After the plant had been in operation a few months an examination showed that the coating in the penstocks was still intact, but in the scrolls, where velocity of water was relatively high, the coal tar was stripped clean in patches exposing the concrete surface, stained dark brown by the absorbed water-gas tar.

Observations in the tunnels of the dam indicated that extremely little

water had penetrated the concrete. Water had entered the tunnels at some contraction joints, but it was not expected that they would be tight. The penstocks and scrolls leaked somewhat in spots, which might have been avoided if the waterproofing could have been applied under more nearly perfect conditions.

In connection with the waterproofing of the dam, concrete test cylinders were made up of a 1:3:5½ mix of wet and dry consistency, cured in damp sand and air for 14 and 3 days, respectively, and given two coats of water-gas tar and one coat of coal tar. On completion of the treatment the test pieces were immersed in water for 7 days and the gain in weight after this period was found to be 1.4 per cent for the wet and 0.9 per cent for the dry-mixed concrete.

Abutment of Hancock-Sullivan Bridge Over Taunton River, Me.—It is known that a treatment of four coats of water-gas tar and a seal coat of coal tar has been applied below water level; but no details of the treatment have been obtained.

General Summary and Conclusions.—From the results of the tests both in the field and laboratory the following conclusions seem warranted.

1. That water-gas tar of the proper quality is readily absorbed by cement mortar and concrete, the rate of absorption varying with the manner of curing, age and density of the mix. Concrete of a 1:3:6 mix cured, respectively, 48 hours and 7 days under moist conditions in the forms followed by 7 days' exposure to dry air, was found to be the most absorptive, while a 1:1½:3 mix, cured 7 days in forms and 83 days in air, was the least absorptive.

2. That the absorption of coal tar by concrete is similar to that of water-gas tar except that the quantity absorbed increases with the time of exposure after treatment with water-gas tar.

3. That a treatment consisting of 4 coats of water-gas tar applied at the rate of about ¼ gal. per square yard of surface, followed by one coat of coal tar appears to afford adequate protection against alkali attack, provided the concrete is of good quality, has been properly fabricated and not leaner than a 1:2:4 mix.

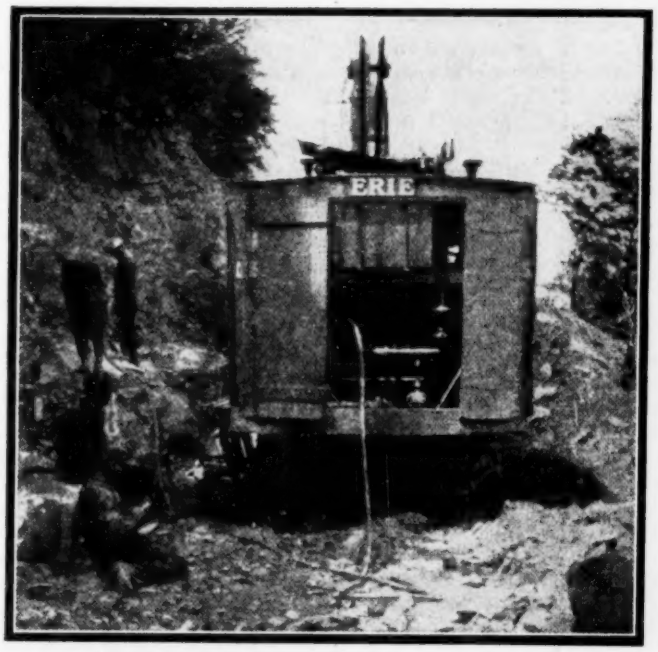
Grading a Pennsylvania Mountain Road

The William C. Horn Company is now executing an interesting contract in Pennsylvania. This contract is for grading nineteen miles of State Highway through the central part of Pennsylvania, along the west branch of the Susquehanna River, from Lock Haven to Hyner. At Hyner the road crosses the river and connects with a new road out of Renovo, Pa. It will take another year to complete the job, until October, 1928.

This road well illustrates the modern ideals of highway engineering, which regard ultimate economy rather than first cost. Low grades and tangents are today sought after in highway as well as in railroad construction.

There are 675,000 cubic yards of earth and rock excavation involved in this contract, an average of more than 35,000 cubic yards to the mile.

Some of the cuts are 95 per cent rock and more than 30 feet in depth. Most of the work is side-hill excavation, although there are many fills over small mountain streams. The road over the mountain will have a maximum grade of eight per cent. It will take the contractor until October, 1928, to finish this big job. Ultimately, the road will be paved. The digging is being handled with five Erie shovels, one steam, and four of the Gas-Air type. The rock is very hard red sandstone and blasting is necessary except where the formation has been cracked by erosion.



Taking Air for Drilling from a Shovel. The Portable Air Compressor Was Not Available So the Gas-Air Shovel Was Drawn Upon, Furnishing Air at a Pressure of 125 Pounds, a Very Satisfactory Expedient.

Ten Miles from Lock Haven Cutting Through 95 Per Cent Rock. The Shovel Is on the Second Lift and Has Another Lift Before Reaching Grade. Material Is Cast Down a Steep Mountain Side.

Action of Alkali on Hydraulic Cements.—The chemical action of alkali on hydraulic cements is the subject of a 56-page illustrated bulletin (No. 74) published by the Iowa Engineering Experiment Station. Experiments were carried out on portland cement and high alumina cement, using magnesium sulphate, magnesium chloride, sodium sulphate, sodium chloride and sodium bi-carbonate solutions. It was found that a magnesium sulphate solution had the greatest destructive action on concrete and next to that, sodium sulphate.

The Development of the Highway

Means of Communication as Aid to Civilization and Early British Roads and Transport Discussed in Paper in Good Roads, Birmingham, England

By SIR HENRY P. MAYBURY

Director General of Roads, Ministry of Transport of Great Britain

Looking backward over the life histories of the notable empires and civilizations one is driven to the assertion that their recognition of the value and need of established chains of communications—not necessarily always by land—has been a rough index of their own permanency, prosperity, and general advancement, in the course of which they not infrequently lifted along with themselves those vassal states which became subject to their domination and sway.

And the decline or destruction of the means of communication of a great state has, in like manner, presaged its eventual decadence from the vanguard of those peoples whose growth and vigor have added most to human learning and advantage.

The Roads of the Roman Empire.—Most notably in the forefront of European civilization appears at the dawn of the Christian Era the restless, far-flung ambition of Rome. That irresistible impulse for expansion flung its legions into all known lands, the conquest of its barbaric peoples being followed by the patient work of her engineers, who drove their roads with simple and direct precision over mountain, plain and waterway, from one place of strength to another. That wave of progress left its trace on the peoples of Western Europe down to our day, but not least in the gift of that great network of roads which, traversing Europe, spread across Britain and was only stopped at the gateway of the wild Caledonian country with the barrier wall of Antoninus Pius, across the line of the Forth and Clyde Valleys. The measure of their activity as pioneers and roadmakers, the value of adequate and soundly constructed roads, may be gleaned from the facts that within the Roman Empire some three hundred and seventy-two great trunk roads were built, aggregating a total length of 52,964 Roman miles, equivalent to nearly 49,000 English miles, and within Britain alone, as far as we have been able to ascertain, no less than 5,000 miles of roads were constructed by them, many miles of which even to this day are incorporated in our present road system, although much, alas, has been lost and destroyed by the hands of vandals, and their component materials removed for other purposes.

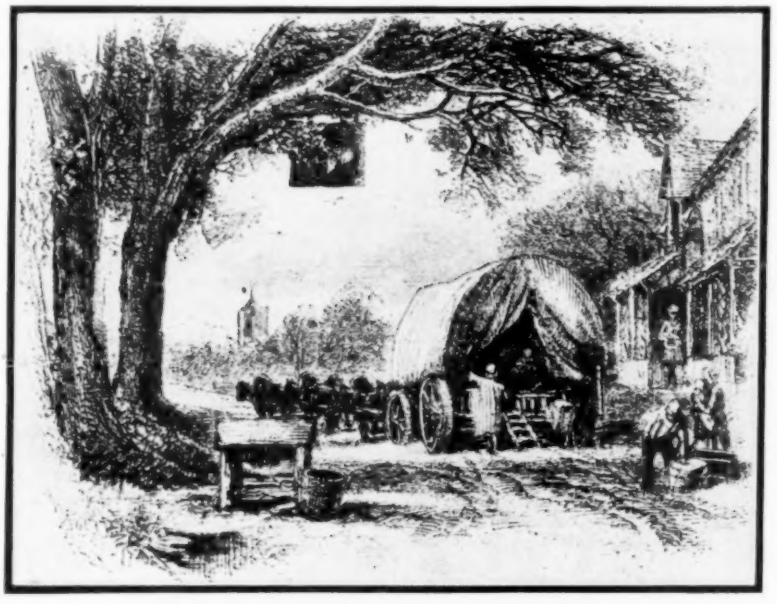
The prosperity of the Low Countries arose from another set of conditions which produced an equally effective solution. The canal and waterways system which the flat plains of Flanders and the Netherlands naturally facilitated, provided a ready and cheap mode of conveyance for passengers and goods which, in the hands of a patient and industrious people, fostered industries and accumulated wealth which stands today reflected in the mediaeval glories of the cities of Ghent and Bruges. More especially in the case of the Netherlands we find a nation whose spirit of enterprise first confined to inland waterways expanded in time into a transmaritime power trading with countries and colonies in the East and West, and thereby providing another parallel in history to the powerful and wealthy development of Spain in pre-Armada days.

The Development of the British Road System.—The slow and gradual development of a road system in England, though to present-day ideas most tardy and casual, still was not out of keeping with the character and needs of its population; yet, when the real necessity arose, the country produced her Telford and Macadam, and the stage coach entered upon a life of great usefulness in quickening the sluggish flow, and promoted movement and intercourse.

The agricultural and national prosperity of that period was quickly followed by the railway and industrial era which established this country as "a nation of shopkeepers," and which saw that wonderful awakening and growth roughly coincident with the reign of Queen Victoria, which girdled the world with channels of communication.

Finally to drive home my point that ready and cheap communications are the forerunners of a nation's prosperity, let us by way of contrast turn to pre-war Russia, whose teeming millions and great potentialities lay like a great giant numbed by her vast distances, and free only to move when snowbound.

Am I really guilty of special pleading if I claim that the cheapness and freedom of a nation's communications are a measure of the freedom and prosperity of her children, or conversely that, in direct ratio to her statesmanship and vigor, so will she seek and secure the blessings of cheapness and economy in her means of transportation?



In Days of Old. Photograph of an Old Drawing

The Growth of Roads.—Considering our subject only from the viewpoint of land routes, let us now pass to the study of the growth of a road.

In virgin country the straightest alignment that can be sited for a new route is the obvious one, and in new lands like the U. S. A., Canada, etc., where the towns have sprung into being with the impulsiveness of the proverbial mushroom, the connecting roads have followed at leisure, and have been located and engineered with the direct-

ness and precision of railways through lands relatively valueless, or at any rate where private ground interests were entirely subservient to the greater need of the community.

To large extent such directness of treatment obtained where military conditions prevailed, as with the Romans, or again as with the French, where the "state" or national view found full expression.

In England our innate reverence for the law of the land and the property of individuals has constrained our movements into the lines of least resistance, and the fact that an early Saxon ancestor was "warned off" the lands of a short-tempered Norman, or made a detour to keep on high ground, explains why the wayfarer of today still follows in the track of his ancestor, and pursues a devious and winding road which skirts but never touches or disturbs the fixed pattern of Farmer Brown's fields.

It is a convention accepted usually without question that the road followed some way after the establishment of an aggregation of houses, and while this is probably true of those towns which have centered upon the strongholds of powerful chiefs or religious institutions, in many other instances the order of growth has been reversed, and towns have sprung into being along the line of more or less established tracks or routes.

Instances of this occur at the fords of a river, e. g., Oxford, Guildford, Hungerford, where the track emerging from dense woods on either bank crossed a river by ford at these points, the rude hut of a dweller on the bank later becoming a rest house and forming the nucleus about which the town grew. This is the accepted theory of the origin of Paris, and is probably equally true of London.

Early Roads in Britain.—The earliest thoroughfares we have in Britain are in the form of "greenways" or tracks for foot traffic. These in all cases were confined to open land—more particularly to high ground or down land—thus keeping clear of forests and undergrowth, and all marshy land. The wayfarer of that day was taught, by hard experience, in the interests of his personal safety, to keep to open ground away from the haunts of wild animals and his still more savage fellow man, and to regard every stranger by the way as a potential enemy.

The Roman occupation of Britain between the first and fifth century completely ignored the use of the old greenways. Their elaborate civilization was withdrawn, leaving behind them their permanent works and all its carefully planned network of permanent roads.

The unsettled conditions of the country supervening, and the inter-tribal conflicts, restored the old condition of ignorance and gloom. The new roads were ignored, and the old tracks again came into use.

Following the Norman Conquest and the creation of more settled centers of human habitation, lines of communication between these began to be more firmly defined by regular use, and from this period onward roads as such first began to form. There appears to have been little display of guidance and forethought, and with the Anglo-Saxon passion for local government with its more immediate outlook, no conception of a national need or co-ordination of effort is traceable.

Indeed, to our permanent misfortune, this attitude has existed right down to recent times. The laws regulating the repair of roads passed on to the statute

The Old Pack Horse Train Crossing the Moorlands in Derbyshire

book, but left the duty and method of securing this end in too indefinite a form. These haphazard and chaotic conditions produce only one result, and we are today the legatees of this narrowness of vision.

The casual conditions which determine the lines of these tortuous and winding country roads are only too closely paralleled by the town conditions of this middle period. It is only necessary to recall the present-day town of early origin to visualize the traffic conditions still perpetuated, the measure of the artistic effect being most frequent directly proportionate to their traffic inconvenience. Houses on narrow roads had been crammed together within the protection of the town walls or the shadow of a stronghold, to secure the structural or moral support of a neighbor.

The construction, if such a term can be used, was inevitably primitive and crude. "Every man's business was no man's work."

In section the roads were narrow, having an extremely barrelled body of excessive camber. The right of the road had a real meaning at a time when the courtesy of moving to one side would almost certainly involve the collapse of the vehicle in the inevitable side ditch.

When a condition of disrepair was reached, two deep parallel gutters or wheel tracks were formed, in some cases sinking through to the native soil below, and with a high central ridge between, which the rains of the wet season reduced to a condition of almost complete impassability. Time taken in simple journeys would seem incredible and much exaggerated.

Apart from the condition of the road, the probabilities of the traveller reaching his destination were greatly weakened unless he joined his forces with others into an armed company. This tended greatly to discourage moving, and the thirst for travel for its own sake, which curses our fretful modern life, was easily kept in check.

Improvements in the laws affecting highways, more particularly those which made a provision for labor and the transport of materials, led to a gradual but slow betterment.

Early Road Vehicles.—Only few and widely scattered historical records of wheel vehicles can be traced down to the year 1533, when a marked revival took place, due to the introduction by Queen Mary of a carriage for her coronation ceremony.

Froissart refers to the use in 1360 of "charettes" by the English Army when returning from the wars in Scotland, but does not describe their shape or form.

In 1380 a vehicle called a "whirlicote" was in use; this appears to have been a kind of cot or couch mounted on wheels, something akin to a special form of litter.

The stage wagon, often drawn by eight heavy horses, appears to have been formally established in 1590 as a common carrier, and for the movement of the peasantry about the kingdom. All others rode on horseback, from the King and Queen downward.

The opening of the coach age for the public in general may be said to have commenced in 1657 with the establishment of the Chester Stage, undertaking a journey from London to Chester in four days. Bitter and frequent complaints continued to be made of the condition of the roads these had to traverse, and even with six stout horses they were at times quite unusable by coaches.

In 1605 records show that hackney coaches began to ply for hire on the streets of London, and from the City of Westminster. Up to this time the construction of these vehicles was of a most solid order. They were springless, heavy and cumbrous, without windows and the least degree of comfort, and a journey of a moderate length was accompanied by severe physical discomfort to the stoutest traveller.

Pepys in his "Diary" records that in May, 1665, he witnessed experiments on the new coaches fitted with springs, "finding them go not quite so easy as their inventor claimed."

The issue of the following announcement in 1670, as one writer states, would at that time have made Londoners stare:

Flying Machine.

All those desirous to pass from London to Bath or any other places on their road, let them repair to the Belle Savage at Ludgate Hill in London, and the White Lion at Bath, at both of which places they may be received in a Stage Coach for Monday, Wednesday and Friday, which performs the whole journey in three days "if God permits" and sets forth at 5 in the morning.

Passengers to pay £1 5s. each, who are allowed to carry 14 lb. weight, for all above to pay three half-pence per pound."

"The six inside intrepid passengers, practiced travellers all of them, had booked for Bath; with a proper regard for the proviso in the advertisements they had committed themselves to Providence; they knew they were going—35 miles a day instead of 20, over roads called so out of courtesy, and the thought now that they were seated gave them melancholy pause; they cursed the curiosity which pines for new experience and wished themselves on the fixed earth again."

This journey of 109 miles from London to Bath by the new coach occupied three days. The stage wagons of that time would probably have occupied six days in the same journey.

Tolls had been enacted by statute in 1346 for the repair of the main roads out of London, and the restoration of Charles II saw the introduction of the turnpike system generally. Much activity prevailed between the years 1700 and 1770, as may be gathered from the fact that no fewer than 530 Highways Acts received the Royal Assent in that period, from which it is hardly necessary to add that practically no useful results accrued.

Telford and Macadam.—The first real impetus and betterment of English roads centers round the names of Telford and Macadam. James Loudon Macadam, 1756-1836, developed a principle for the formation of roads under the macadamized system. Two conditions were specially emphasized by him:

1. All stones were to be broken up to angular fragments of 2½ in. maximum diameter, and of a weight not exceeding 6 oz. each; and

2. No binding material was to be added to the stone for filling the interstices.

3. No special foundations were necessary. It was sufficient if an adequate thickness of broken stone was spread to distribute the weight.

His principles attained a great vogue, and the improvement of roads, and particularly the surface condition, was very noticeable. His methods were widely adopted on the Continent, particularly by French engineers. He was appointed the first Surveyor General of Roads Trusts in 1827.

Thomas Telford, 1757-1834, his contemporary, also achieved great fame as a road engineer, and was sent by Parliament to prepare schemes for the development of the Highlands, which ultimately involved the construction of 1,000 miles of new roads and over 100 bridges.

Telford's system of construction essentially provides a special foundation which was to consist of wedge-shaped pieces of rock placed in the bottom of the road on their bases as a foundation,

At the Toll Bar or Collecting Station on the First Form of Turnpike Road

the spaces between the wedges being carefully filled by hand with smaller pieces of stone to wedge the whole tight, the surface of this pavement then being covered over with broken stone to form the road surface.

Both systems had their advantages and their faults, and the practice in more recent years has trended in the direction of compromise, employing the best features of both methods.

The results of their efforts obtained a general improvement in the English road system. Their success was all the more remarkable as the system of rolling the new material by horse rollers was not introduced until the year 1830. A still greater improvement was effected by steam rolling, the first practical machine of this character being made by Messrs. Aveling and Porter in 1863.

To complete the history of the control of highways the unit of administration at this period was the Parish. The Public Health Acts and Local Government Acts passed from 1875 onward placed the local government on a firmer and more logical basis, and established the Rural District Council, the Town Council and the County Council, as authorities for the control and administration of highways. The increase in size of the unit of control to a county will be observed.

The next notable change follows the re-introduction of the mechanically-propelled road vehicle both in the form of the heavy steam tractor and the petrol driven motor car introduced from the Continent. The legislation was framed to deal with and control this new form of traffic, and in 1909 the first State Department charged with the duty of maintaining a control over highways from a national standpoint was set up in the Road Board. This department was credited with funds derived from the taxation of motors for expenditure in the improvement of roads and road surfaces to meet the new traffic conditions.

Development of Modern Transport.—The latter portion of the eighteenth century and the first quarter of the nineteenth century saw the heyday of the stage coach on English roads.

Into these conditions came the railway era, beginning with the opening of the Stockport and Darlington line in 1826. This new form of locomotion commended itself so much to the public and to the investors that capital was freely subscribed and construction proceeded so rapidly that in 1848 the last long distance stage coach was run off the road when the "Bedford Times," which ran between the Swan Hotel, Bedford, and the George and Blue Boar, London, doing the journey (including stops) at 10½ miles per hour, was finally withdrawn.

Towards the later stages of the life of the horse-drawn stage coach, the inventive genius of the country was turned in the direction of devising a self-propelled machine for roads capable of doing the same work. Several successful or partly successful machines were evolved. William Murdoch in 1784 constructed a working model which functioned satisfactorily in that form but was, however, persuaded to discontinue, and did not, in fact, patent his invention.

Trevethick and Symington also took up this problem, but the most successful efforts at a later stage were those of William Hancock and Goldsworthy Gurney. Gurney's design achieved considerable success, and contained, among other features, a faultless boiler designed on "philosophical principles," and so that if it burst it would harm no one! Unfortunately the "philosophical boiler" burst in one of the carriages running in Glasgow in 1831, and two

boys were seriously hurt. This incident caused Tom Hood to write:

Instead of journeys, people now
May go upon a Gurney,
With steam to do the horses' work
By power of attorney.

So with a load it may explode,
And you may all be undone,
And find you're going up to Heaven
Instead of up to London.

Much opposition and prejudice arose against this form of locomotion from sources more or less directly affected. Despite opposition and the difficulties of the time, Gurney persevered and established services which ran out of London to Liverpool, Manchester, Brighton, Southampton, Birmingham and Holyhead, which secured such a faith in this principle that a Select Committee of the House of Commons, appointed to consider the whole question, reported:

That these carriages could be propelled at an average rate of 10 m.p.h., and would become a cheaper and speedier mode of conveyance than horse coaches, and that they were perfectly safe(!).

A Parliamentary Committee also expressed the opinion that Gurney's machines "were foremost for practical utility," though it is certain that William Hancock was equally successful with his invention, and also established road services. In 1831-1832 he had plied for public hire with an omnibus between Stratford and London, and between Paddington and the city had organized the regular running of three vehicles. So successful was he that journeys were run to Brighton which gave great promise. The action of the Turnpike Trusts in adversely raising their tolls against the steam coach was a severe handicap, and greatly assisted in checking new locomotion. Tolls between Liverpool and Prescot amounting to 4/- for a coach became £2 8s. for a steam carriage, and between Ashburton and Totnes the 3/- toll for a stage coach was raised against them to £2.

Railways, which were now freely attracting capital, became their greatest opponents, and by 1838 they were finally defeated, and withdrew from a contest they could no longer maintain; the development of the road traction, and the mechanically self-propelled vehicle, was thereby to receive a setback of over half a century.

It is a most interesting speculation to attempt to visualize the position of eminence and public advantage to which we might have attained today, if such a notable mechanical progress and development had been continued without restraint or hindrance.

Growth and Evolution of Modern Road Vehicles.—The growth of the modern road vehicle is a page of real romance in the history of engineering. It has grown into its present form as the outcome of patient trial and error, of inventive skill and logical scientific research.

We have known the historical fact that for over 50 years road transportation by mechanical means fell into abeyance, invention being mainly centered upon the development of rail locomotion for passengers and goods, both for long and short distances. Indeed, this development was carried to such an unwise limit that over-capitalization ensued, and costly engineering works were embarked upon to secure a meagre and profitless revenue.

In the Days of the Mail Coach

Meanwhile Fowler and others in England had developed a steam vehicle for agricultural purposes, which was found of great value for steam plowing, threshing, etc.

The power of movement by road under its own steam, which was necessary to enable it to travel about the country and from farm to farm, did in fact evolve as a secondary condition a road tractor for the haulage of its accompanying vans and machines, and this type of vehicle in time more definitely crystallized out as a tractor.

The evolution of this type had been derived from locomotive practice, inasmuch as the boiler was in its first form a horizontal one, the forward end of which was carried on a pair of steerable road wheels, the main driving wheels supporting the rear end and connected by simple gearing to the motion and cylinders mounted on top of the boiler.

The boiler has become smaller and more efficient; in some forms the boiler is changed to a vertical type. Superheated steam and a well-designed engine and transmission have resulted in the production of a most useful tool, and an excellent example of British engineering practice, upon the manufacture and use of which this country stands pre-eminent.

The internal combustion engine which had been evolved for stationary power work, using gas fuel, was experimented with by Gottlieb Daimler and Carl Benz in 1885 in Germany. Daimler endeavored to adapt a small, high-speed, vertical gas engine, modified to use petroleum spirit, and fitted in the first instance to a stoutly-constructed bicycle, and later to four-wheeled vehicles. He achieved moderate success in this direction.

Panhard-Levasseur, in 1894, constructed and introduced in Paris a road motor car using this form of engine. The value of his original work lies in the extraordinary fact that the general layout of his engine and car contained salient features which have not varied to the present day. The engine was vertical and placed in front; the crank and transmission shafting was centrally placed on the main axis of the vehicle; a friction clutch and a variable speed gear was used, the final transmission to the road wheels being by chain drive.

The fuller perfection of these details has, since 1894, absorbed the attention of scientific designers and engineers, and the result obtained within the ensuing ten years was remarkable. Within that time the efficiency of the motor improved enormously despite its own serious mechanical defects. The engine was capable only of small power reserves to meet variations in its work due to changes in the road gradients, or increase or decrease of dead load.

It developed its best power results under uniform or nearly constant engine speed, and to meet these fluctuations in load the gear box was introduced to adjust the engine power more closely to its load. This latter feature is by far the most unmechanical and inefficient link in the petrol motor, but no other device has successfully replaced it. M. Renault, the famous French motor engineer, exclaimed when he first saw the gear box: "It is barbarous, but it works."

The speed and road trials for the elimination of faults and weaknesses

have advanced the design and improvement of the road motor, and the popularity of the bicycle created a taste for the open road which readily led to the development of a market for pleasure cars.

The adaptation of the engine of the pleasure car to the purposes of the commercial motor was a simple and obvious transition, and the rapidity with which the new locomotion succeeded in establishing itself is reflected in the census of vehicles of all natures in use in the British Isles, which, in 1909, was estimated at 100,000 vehicles, in 1920 at 750,000, and, at the present time, at 1,294,000. In America it is credibly stated that the number of cars works out throughout the United States on an average of one per 5½ of the population, and in Great Britain one per 40 of the population.

Texas Passes Subcontract Bill

Governor Signs Senate Bill No. 34 Exempting Contractors From Subcontract Debts

The financial loss and annoyance suffered by public works contractors in Texas on claims against their subcontractors which come to light after the job is completed and settlement made is remedied by the passage of Senate Bill No. 34, which has been signed by Governor Moody, of Texas, and, under the emergency clause, is now a law in that state.

The act provides that general contractors on pubilic work, or their bondsmen, shall not be liable for labor or material furnished to subcontractors on the work unless notice of such claim is filed not later than thirty days after its accrual, either with the contractor or the county clerk of the county where the work is located.

The bill further provides that claims against the subcontractor originating prior to the date of the contract by which he comes on the work cannot be set up for collection under the bond. This is complete protection against prior liens on the subcontractors' equipment or machinery which accrued on former jobs.

The full text of the bill follows:

"An Act amending Article 5160 of the Revised Civil Statutes of 1925; providing more adequate and better regulations and provisions in connection with bonds where a person or persons, firm or corporation enter into a formal contract with this state or its counties or school districts, or for subdivisions thereof or any municipality therein for the construction of any public building or the prosecution and completion of any public work; prescribing what bonds shall be executed in connection therewith and the obligation that they shall contain relative to making payments to all persons supplying labor and materials in connection with the contract; providing more particularly what debts shall be secured by said bonds and providing for filing claims under oath with the contractor or with the county clerk; providing all things necessary and incidental to any such bonds and to the subject and purpose of this Act whether mentioned in detail in this caption or not; and declaring an emergency.

"Be it enacted by the Legislature of the State of Texas:

"Section 1. That Article 5160 of the Revised Civil Statutes of Texas be amended so as to hereafter read as follows:

"Article 5160. Any person or persons, firm or corporation, entering into a formal contract with this state or its counties or school districts or for subdivisions thereof or any municipality therein for the construction of any public building or the prosecution and completion of any public work shall be required, before commencing such work, to execute the usual penal bond, with the additional obligation that such contractor shall promptly make payments to all persons supplying him or them with labor and materials in the prosecution of the work provided for in said contract. Any person, company or corporation who has furnished labor or materials used in the construction or repair of any public building or public work, and payment for which has not been made, shall have the right to intervene and be made a party to any action instituted by the state or any municipality on the bond of the contractor, and to have their rights and claims adjudicated in said action and judgment rendered thereon, subject, however, to the priority of the claims and judgments of the state or municipality. If the full amount of the liability or the surety on said bond is insufficient to pay the full amount of said claims and demands, then, after paying the full amount due the state or municipality, the remainder shall be distributed pro rata among said intervenors. Provided further, that no person, or persons, firm or corporation shall be secured in the payment of any claim contracted prior to the execution of the contract that said bond is given to secure, and provided further that all claims for labor shall be itemized and sworn to by the owner or his authorized agent and filed with the contractor or with the county clerk of the county in which said work is being prosecuted within thirty days from the date that said claim accrued and became payable, and all claims for material shall be itemized and sworn to by the owner or his authorized agent and filed with the contractor or with the county clerk of the county in which said work is being prosecuted within thirty days from the date of the delivery of said material and any claim filed after said thirty days shall not be secured by said bond.

"Sec. 2. The fact that there is now no law providing that persons, firms and corporations shall not be secured on the contractor's bond for claims made prior to the contractor's contract, and further, there is no law requiring the filing of said contract within a reasonable time creates an emergency and an imperative public necessity that the constitutional rule requiring bills to be read on three several days in each house be suspended, and said rule is hereby suspended, and that this Act shall take effect and be in force from and after its passage, and it is so enacted."—Lone Star Constructor.

$1,000 in Prizes Offered for Highway Safety Suggestions

Prizes totaling $1,000 have been offered by the American Road Builders' Association for the best ideas for reducing the number of highway accidents occurring each year. The contest, which is being held in connection with a national safety campaign, is open to everyone. It will close midnight Nov. 15th.

More than 114,000 persons have been killed and nearly 3,500,000 injured during the past five years as a result of highway accidents, the association stated in explaining the need of such a campaign. Last year the accident toll was 25,302 killed and 759,060 injured, and the economic loss resulting from accidents was $638,875,500. The figures have been mounting steadily for five years.

The American Road Builders' Association, which is the world's largest organization representative of the highway industry, has inaugurated its safety drive in an effort to start the accident figures on a downward path. The contest, designed to bring out new ideas for safety, is an important part of the campaign.

First prize in the contest is $500. There will be nine other prizes, totaling $500. The awards are offered for "the best workable plan that will decrease street and highway accidents." "The plan," the association explains, "may be a complete comprehensive thesis covering the entire subject or a mere description of a single idea that would contribute to highway safety. The plan must be practical and capable of being put into operation at reasonable expense."

Winners will be announced in the press and by radio Jan. 11, 1928, during the annual convention and road show of the Association in Cleveland Jan. 9 to 13. A report compiled from the ideas submitted for the contest will be presented to the convention.

Road Work in Rain and Flood

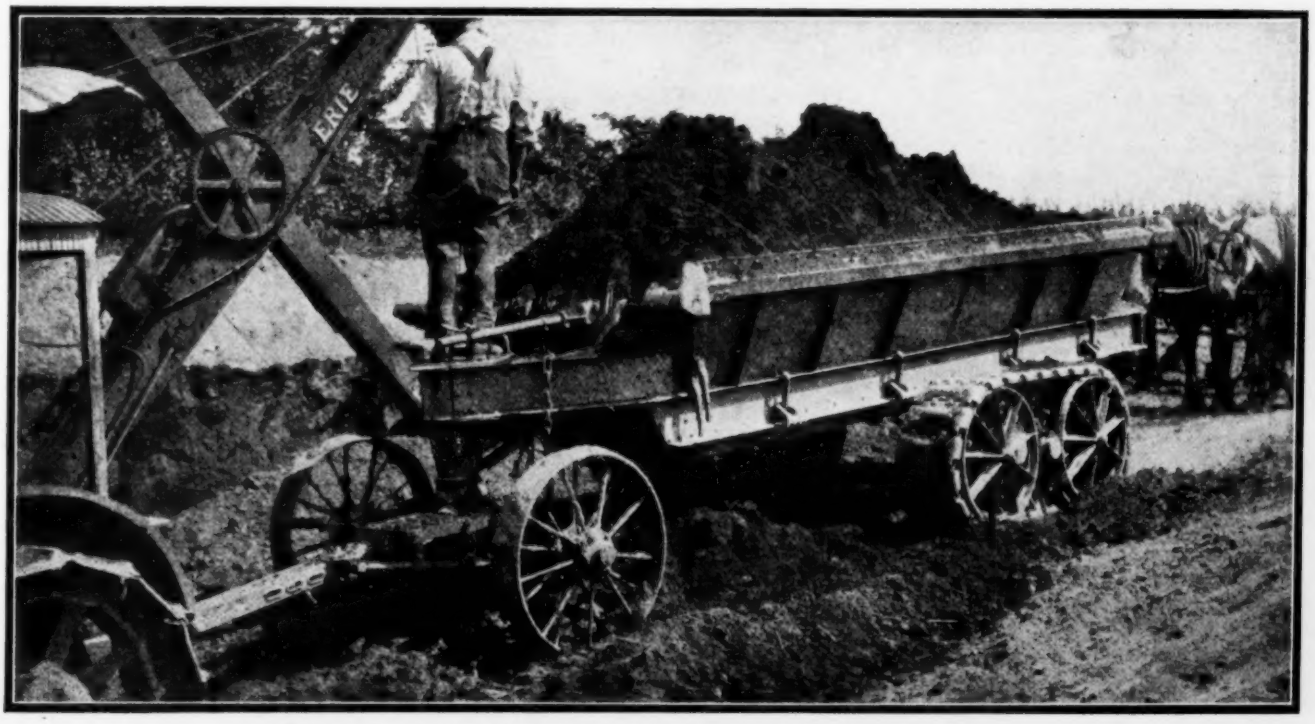
How an Interesting Grading Job Was Done With Unusual Equipment

An interesting dirt moving job, described in the "Earth Mover," done in Illinois by S. J. Groves & Sons, a Minneapolis firm, involved the grading of two and one-half miles of road about eleven miles north of East Peoria. Here a new type of equipment was used for the first time, the Western 7-yard Crawler Dump Wagon on Athey Truss Wheels.

The first work done was on the hill shown in one of the illustrations. The largest cut on the contract was on this hill. Springs of water, soft spots, and sticky clay were encountered. Heavy rainfall, added to these difficulties, made the work particularly slow. For a time it was necessary to use two dumps, because the springs were so numerous and persistent. Material was placed in one dump until a layer had been put in. This was then allowed to dry out and the material placed in the second dump.

On this particular job both horse-drawn 1½ yard dump wagons and the

An innovation in Illinois road work. A Western 7-yard Crawler Dump Wagon under the shovel. The broad rear wheels carry 90 per cent of the load and thoroughly pack the fill. The material is a sandy clay, very soft and fluffy when loosened



Piling on the dirt. There is nearer nine than seven cubic yards on this load.

A good view of the job. The road comes down the hill on a 3 percent grade.

7-yard Crawler Dump Wagon were used. The ten 1½ yard dump wagons were each pulled by three horses or mules and a "caterpillar" 60 furnished the power for the 7-yard wagon. The 7-yard wagon was hauling about one and one-half loads to the dump while the ten one and one-half yard wagons hauled one load each. The ⅞-yard Erie shovel that was doing the digging was never idle a minute waiting for wagons. This combination kept one Chicago Tongue Scraper and sometimes two busy all the time.

The work began about the middle of April. As every contractor knows, there was plenty of rain about that time. Floods washed away 1,500 cubic yards of earth already placed in embankment and caused in all at least a month's loss of time.

In spite of all the rain, water was hard to get for the steam shovel and the stock. While working on the hill, it was necessary to dam a creek and pump the water up hill fifteen stations for the shovel. The camp, about a quarter of a mile away, was supplied by a well.

The firm of S. J. Groves & Sons consists of Frank M. Groves, President; C. H. Groves, Vice-President; Frank F. Kippley, Secretary and Treasurer. Carl Craven is superintendent in charge of this work and R. C. Flake, foreman.

Utilization of Blast Furnace Slag in Highway Improvement

A technical series bulletin dealing with the above subject has been issued by the Missouri School of Mines. The author is Clarence E. Bardsley, Associate Professor of Civil Enginering.

The work was undertaken by the author as a dissertation in partial fulfillment for the degree of doctor of science under the National Slag Association Fellowship in Highway Engineering and under the direct supervision of Dr. Arthur H. Blanchard, Professor of Highway Engineering and Highway Transport at the University of Michigan, leave of absence having been granted the author from the University of Missouri for the year 1926.

Professor Bardsley follows the discussion on the nature and purpose of the investigation with his chapter I, which gives a resume of the History, Manufacture, and Use of Slag as a Structural Material. He sketches the history of the uses of slag from the earliest Roman times through Germany, England and other countries in Europe and the Orient to its present uses in the United States. A concise description of the manufacture of slag is taken up from the processes at the blast furnace up to the time it becomes a construction material. Slag as a structural material is then described and its uses discussed. This discussion is concluded by tables summarizing the specifications for slag in higway construction as given in the specifications of many state highway departments, the U. S. Bureau of Roads, etc.

Dr. Bardsley's chapter II discusses tests on blast furnace slag—their interpretations and conclusions. This portion of the report has been abstracted. It is stated that those interested in the actual tests are privileged to examine the full report which contains over 300 pages and is on file in the Library of the Graduate School at the University of Michigan, Ann Arbor, Mich.

Chapter III summarizes on 8 pages his conclusions from the tests mentioned and the general study made, and recommendations are given for further study where little information was available. A symposium of the tests available in this study are given at the end of the chapter.

The next 75 pages of the bulletin comprises the extensive bibliographics on blast furnace slag: the first being given according to kind of publication and alphabetically arranged, and the second consisting almost entirely of a different series of references chronologically arranged.

This bulletin contains 115 pages and 17 illustrations; 8 tables, 39 pages of descriptive matter and a bibliography of 600 references. Copies of the bulletin may be obtained on application to the librarian of the Missouri School of Mines, Rolla, Mo., or to the author. Address requests on letter-heads.

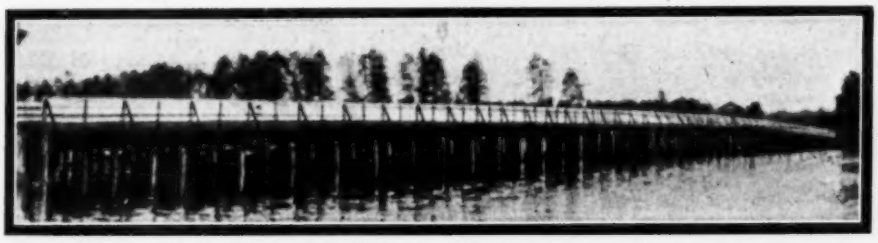
First Concrete Highway in Argentina.—The contract to construct a concrete highway between Moron and Lujan, Argentina, has been awarded to Andres Barberis, Nealle Florida, 329, Buenos Aires, Argentina, the bid being approximately $2,209,012. The road is 53 kilometers in length, and is said to be the first concrete highway constructed in Argentina.

Creosoted Timber Highway Bridge at Minocqua, Wis.

By C. H. KIRCH

Bridge Engineer, Wisconsin Highway Commission

The Wisconsin Highway Commission has recently completed Federal Aid Project No. 431-B, which consists of a bridge over Lake Minocqua at Minocqua, Oneida County, on U. S. Highway No. 51. The bridge replaced was an untreated timber pile trestle built in 1912, about 850 ft. long and with a 16-ft. roadway. The water has no current, but is 25 ft. deep near the center of the bridge. There is then approximately 10 ft. of muck and soft sand before firm bottom is reached. The grade of roadway at the center of the bridge is about 12 ft. above water, making a maximum distance from grade to firm bottom of 47 ft.



Creosoted Timber Bridge on Federal Aid Project No. 431-B, Minocqua, Wisconsin. Note Three-Lane Roadway, Double Sidewalks, and Pleasing Effect of Camber

The old bridge was in an unsafe condition, and, as the local municipality and county were unable to finance a new bridge, a federal project was made out of it. It can be seen that to build a steel or concrete bridge at this location and to carry foundations to good bottom would be quite an expensive proposition, and, since the bridge was to be built with state and federal money only, a structure was desired which would take care of the situation and which could be built at a reasonable cost in order not to draw too heavily upon these funds. A creosoted timber pile trestle was therefore decided upon.

The structure as built is 831 ft. long, and is made up of fifty-four spans with bents at 15-ft. centers and one 21-ft. span at the center of the bridge to allow for passage of boats. The structure is crowned to allow a vertical clearance for passage of boats at the center and to meet the grade of the road at the ends of the bridge. The roadway is 27 ft. clear between curbs and there is a 5-ft. clear sidewalk on each side of the roadway.

The railing consists of 4-in.-by-4-in. posts with 2-in.-by-6-in. rails properly braced. The roadway joists are 6-in.-by-16-in. timbers. The floor is of the laminated type, made up of 2-by-4's on edge, spiked together, upon which was placed a built-up tar mat wearing surface.

Each bent was made up of eight piles, double crossed braced, and with a 10-in.-by-12-in. cap. The length of piles used varied from 30 ft. to 60 ft., depending upon their location in the structure, but the 60-ft. length predominated. Heads of all piles under caps, after being cut to grade, were treated with hot creosote oil and covered with a sheet of zinc, No. 12 zinc gauge. All piling were driven from the ice during the winter, and the entire structure was built at that time, exclusive of the placing of the wearing surface, in nine weeks.

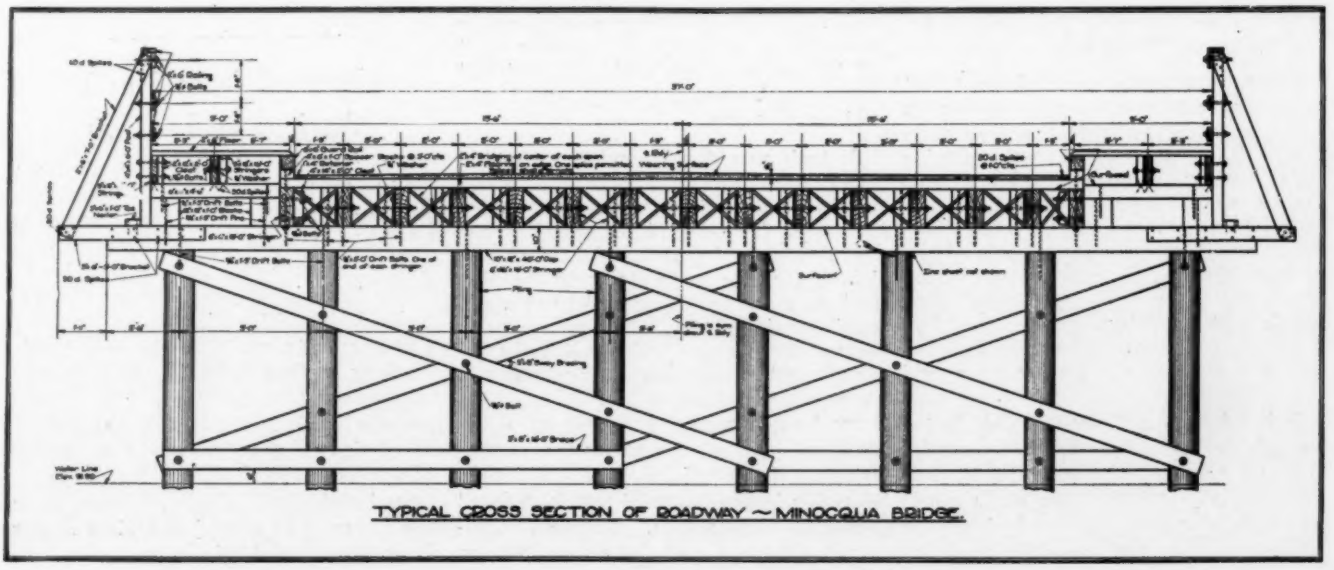
In preparing specifications for this work, those of the American Association of State Highway Officials, with respect to materials, methods of treatment, and preservative oils, were followed very closely, and which we believe are almost the same as the requirements of the American Wood-Preservers' Association. The piles used were of yellow pine and the timber used was of Douglas fir. All piles and 12-in.-by-12-in., 10-in.-by-12-in., and 6-in.-by-16-in. timbers were treated with not less than 14 lb. of oil per cu. ft. of timber. All other timber and lumber was treated with not less than 12 lb. of oil per cu. ft. of timber.

The quantities involved are as follows:

Treated timber	279,000 bd. ft.
Untreated timber	7,000 bd. ft.
Treated piling	21,360 lin. ft.
Sheet zinc pile covers	448 pieces
Wearing surfaces	25,000 sq. yd.
Miscellaneous hardware	

This work was done by contract. Bids were advertised for and ten bids were submitted, of which the lowest was $58,783.20 and the highest was $76,-077.55. The contract was awarded to the lowest bidder, who successfully carried out the work. The work done by the contractor in connection with the construction of this bridge is of high-class workmanship, and, we believe, is a credit to all who were connected with it.

It is believed that this type of construction was ideal for the existing conditions. To build a steel or concrete structure at this location with the conditions as they existed, and with the width of roadway and sidewalks, probably would have cost about four times the cost of the treated pile trestle.—Wood Preserving News.



TYPICAL CROSS SECTION OF ROADWAY ~ MINOCQUA BRIDGE.

Road Building Through a Desert

Future automobile tourists crossing Imperial Valley, California, between Yuma, Arizona, and San Diego, will motor over a handsome macadam road that considerably shortens the distance between those cities. The new pavement leaves Yuma Highway about 15 miles southeast of Holtville and extends in a westerly direction to Calexico, California, on the Mexican border; then turns north to Seeley on the San Diego Highway. The 44 miles of new County Highway when completed will have cost more than $1,125,000.

The first unit of 32 miles recently was completed by Wells & Bressler of Santa Ana, California. Their contract was for approximately $584,000. It was the largest single contract let for paving by any county in southern California within the past two years and the largest road contract ever let in Imperial Valley. Wells & Bressler's work involved the placing of 1,728,909 square feet of six-inch, and 820,326 square feet of five-inch asphaltic macadam, in addition to grading and construction of shoulders. Not one motorist in a thousand, hurrying over this road to reach California, will realize the difficulties and discomforts of the construction period.

The contract was let in August, but work did not start until October, in order to avoid the intense heat of summer. This may seem unreasonable delay to some eastern contractors who do not realize how hot it gets in Imperial Valley; 120 degrees in the shade is not at all uncommon, and there is no shade. Much of the actual construction work was through a desert paralleling the international border line about two miles distant, where the dust was a foot deep,—a fine silt filling eyes, ears, and lungs of mules and men. This silty soil is of such a character that it required the construction of a special sub-grade and shoulders of disintegrated granite. Nearly 7,000 cubic yards of disintegrated granite had to be placed in two and one-half miles of road through this desert silt. The grading of the highway required a total excavation of 126,215 cubic yards and a total fill of 68,497 cubic yards.

The character of the macadam laid and the method of laying it will be of interest to contractors in other states. Four sizes of material were used, ordinarily designated by their numbers. No. 1 is rock, small enough to pass through a 3½-inch screen and large enough to be retained on 1¾-inch screen. No. 2 passes through a 1¾-inch screen and is retained on a ¾-inch screen. No. 3 passes a ¾-inch screen and is retained on a ¼-inch screen. No. 4 is fine screenings.

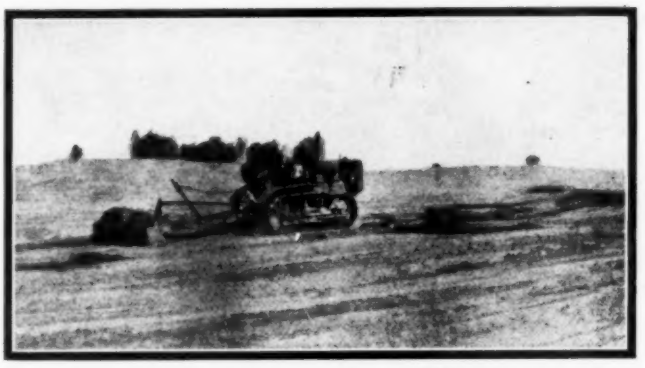
The method of construction was to spread approximately five and one-half inches of No. 1 and roll it down to a compact layer, four inches thick. Screenings were then spread over this to fill all voids. The surface was then broomed with hand brooms to a depth of ¾-inch to one inch. A second course of No. 2 material was then spread to a thickness of from 1½ to 1¾ inches, when compacted under the roller. After rolling, this layer was sprinkled lightly with water, not enough to wet the subgrade, then asphaltic oil was applied, from ½ to ⅝ of a gallon per square yard. The surface was then covered with No. 3 material and again rolled and wet. The last step was to apply from ¼ to ½ gallon per square yard of 95 per cent asphaltic oil, finished with No. 4 screenings and rolled and wet once more.

It took an extensive outfit to do this work, including nine rollers, 25 to 30 trucks, road graders, "Caterpillar" tractors, etc. The contractor maintained a completely equipped tool house on the job, with spare parts for every machine and a man in charge. The district engineer in charge of the work for Imperial County, Paul E. Kressly, of Los Angeles, says that he never saw a more complete tool house. That might have been expected, however, of Wells & Bressler, who rank very high as contractors in southern California. Mr. Bressler is President of the Associated General Contractors, Southern California Chapter, and there are no more wide-awake contractors in the United States than the members of this chapter.

Southern California and the neighboring states of Nevada and Arizona seem to offer a fertile field to contractors of that section. Mr. Kressly, consulting engineer representing Imperial County in the road work described, is a living illustration of construction activities in southern California, as well as of its far-famed climate. A few years ago, Mr. Kressly, "back east," was given only a short time to live and, like so many others, went out to Los Angeles to spend his remaining years in the sunshine. He hung out his shingle in Los Angeles as Consulting Engineer, and since then, up to the present time, has handled work costing $52,000,000, and is the picture of health.

The new road, in addition to giving thousands of automobile tourists a short cut across Imperial Valley between the east and west, will facilitate the transportation of produce raised on 250,000 acres of intensively cultivated land. Imperial Valley is the hot house of America. Its desert soil, that makes road building so difficult, needs only the touch of water and a gardener's skill and energy to produce almost unbelievably.—Earth Mover.

P & H 206 Shovel Borrowing Dirt from Irrigation Ditch Bank



"Caterpillar" 30 Tractor Pulling a Rotary Fresno in the Sand Dunes

Run-off from Small Agricultural Areas

An article entitled "Run-off from Small Agricultural Areas," by C. E. Ramser, Drainage Engineer, reprinted from the Journal of Agricultural Research, volume 34, No. 9, will be of interest to highway engineers. The report deals with rainfall and run-off measurements made on six watersheds ranging in area from 1¼ to 112 acres in Madison County, Tenn. The results are applicable to the design of all types of drainage structures where similar conditions exist. Copies of this report may be obtained without charge from the Office of Information, United States Department of Agriculture.

New Stump Pulling Device

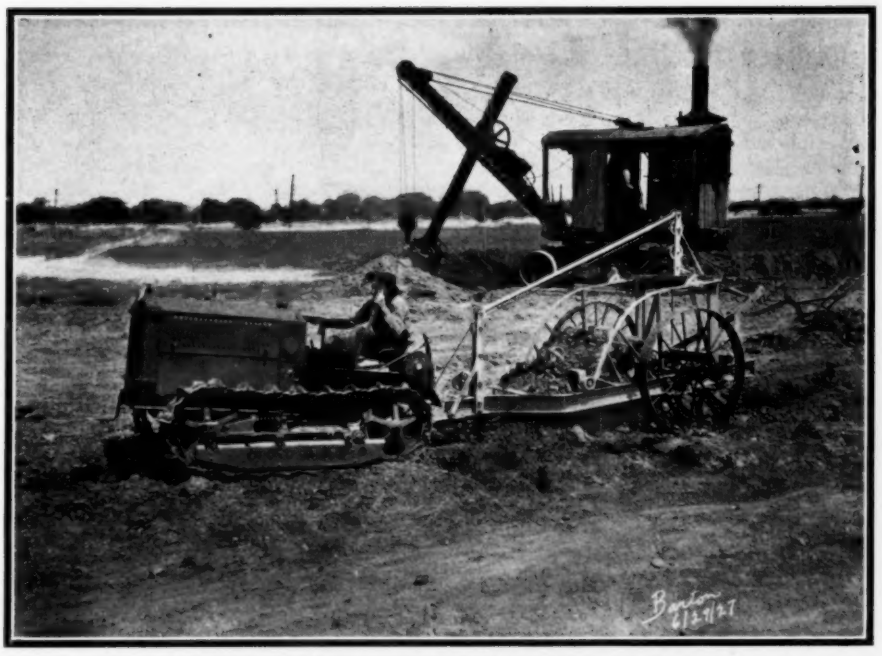
The clearing and grubbing on Florida State Road Department's Project 677-C Road number 13 in Levy County was recently performed in record time by the use of several gasoline dragline machines equipped with a new device for pulling the stumps and for piling the stumps and logs preparatory to their being burned when dry.

The location of the work in Levy County is through what is probably the heaviest clearing and grubbing to be encountered anywhere within the borders of the state. The road runs through swamp land known as "Gulf Hammock," being covered with a dense growth of large timber and under water during the rainy season.

The stump puller itself which weighs about 1,600 lb., is made from two pieces of 6 by 6 in. iron hinged at one end so as to open and close like a giant nut cracker. The power for pulling the stumps was supplied by several P&H cranes, the "Nut-Cracker" itself being swung from the point of the boom by hoisting cable, while the stump is pulled by the dragline cable. The larger sized stumps are loosened or split by the use of explosives thus speeding the pulling operation as well as aiding in the burning of the stumps at a later date.

The puller itself is automatic and needs only the operator on the dragline machine to place the puller on the stump, pull it out, swing the boom and deposit in piles along the right-of-way. No hand work is required to fasten the puller to the stump nor to release the stump from the puller when in position to drop. Among the unique qualities of the machine is the arrangement of the cables so that the harder the pull on the cable the tighter the grip of the puller on the stump.

The stump pulling device was invented by Chris Webster of the contracting firm of Boone & Webster, Cedar Key, Fla. Patents for it are now pending.



New Miami Power Scraper Designed for 20-K Cletrac Tractor

New Power Scraper Uses 20-K Cletrac

A new model of the Miami One-Man Power Scraper has been produced for use in connection with the Model 20-K Cletrac Tractor by The Miami Trailer-Scraper Co., Troy, Ohio. The photograph on this page shows the Scraper and Tractor in actual use.

The Miami One-Man Power Scraper is exactly as the name implies, a power scraper whereby one man or the tractor driver loads, transports and automatically dumps a full three-quarters of a yard of earth each and every trip without stopping the tractor. The above is the water level capacity of the scoop pan. The scoop pan can be filled with a full rounded load of earth running from 21 to 24 or 25 cubic feet, say the manufacturers.

It is impossible to stall the Miami Scraper, it is claimed, for the scoop pan of the Miami scraper is always under the control of the operator who raises it or lowers it as desired. This control is positive through the Miami power winch which is furnished with each scraper and which mounts on the tractor. The positive control of the scoop pan through the Miami power winch enables the driver to dump the load whenever or wherever wanted.

Roller bearing wheel equipment allows the unit to be placed in many difficult positions both for loading and for dumping. After the pan is filled to capacity the driver pushes forward on the lever and raises the pan out of the ground so that the front end is at about a 15 degree angle. In this position the load is transported to the dump on roller bearing wheels with a very slight loss even of a full rounded load. The Miami Scraper delivers its pan capacity to the end of the haul each and every trip.

Stump Puller Ready To Be Put on Stump, and in Operation with Partially Pulled Stump Coming Out of the Ground

Super Energy Magnetos Announced by Robert Bosch

A new "Super-Energy" line of magnetos has just been announced by the Robert Bosch Magneto Company, whose Original-Bosch magnetos have held a prominent place in the automotive industry since their introduction in 1887. This company states that this new line represents the first radical development in magneto design for the past 17 years, and makes available in a complete range of magneto sizes suitable for gasoline engines from the smallest motorcycle to power plants ranging to 500 h. p and upward.

One of the New Line of Bosch Magnetos

"Super-Energy" magnetos are offered to manufacturers and users of all internal combustion engines as embodying features not hitherto available in units of corresponding size and price. Their high output at low speeds facilitates starting on the magneto, which is now generally possible at low hand crank speeds, according to the manufacturer. Improved heavy pulling on hills where slow speed and high compression may cause missing from less powerful ignition equipment is gained. Other characteristics of performance include high electrical output, maximum operating speeds much in excess of those of present day engines, permanently lubricated bearings, fewer sizes covering a wide range of uses, compact streamline construction, both dustproof and waterproof.

"Super-Energy" magnetos embody many technical features which make possible their good performance, it is said. These include new design of electrical construction such as permanent magnets, winding armatures, and distributing parts for high output and efficiency. At the same time, parts are made more rugged and less liable to damage even if roughly handled. For example, distributor plates are made of a practically unbreakable composition developed for the purpose. They are made smaller in diameter than those of former models to reduce distributor brush surface speeds. At the same time the amount of insulation between segments is increased.

New Oil Burning Tar Heater

A new tar heater designed especially for burning oil economically and with maximum efficiency has been placed on the market by the Jos. Honhorst Co., 1016 W. 6th St., Cincinnati, O.

New Oil Burning Tar Heater

The oil burner is of the torch type and burns kerosene. Baffle plates distribute the hot gases evenly, so that kettle is completely enveloped in flames. This arrangement produces an extremely high temperature in minimum time. Flame may be regulated to control temperature.

Special Body for Hauling Wet Concrete

A new dump body designed especially for hauling wet concrete has been placed on the market by the Hug Co., Highland, Ill.

The new Hug body is of the rear bottom dump type and remixes the batch in the dumping process. The operation of the body is automatic and is of unusually simple construction. As the body is raised with a 6-in. hydraulic power hoist operated directly from the driver's seat box, the entire body shell is elevated by toggle arms in such a manner that the batch in falling through rigid cross members of the body is remixed in the process of dumping. The wet concrete is discharged at the rear of the body in the usual manner.

The development of the new type body is credited to C. J. Hug, President of The Hug Co., who thereby adds another distinguished achievement to the numerous designs and patents he had already developed for the Hug Roadbuilder truck and other roadbuilding machinery bearing the Hug name.

Transmission of Wheel Loads.—Formulas for the transmission of wheel loads to culverts through various thicknesses of cover are included in bulletin 79, an 80-page illustrated bulletin published by the Iowa Engineering Experiment Station, Ames, Iowa, under the title of "Experimental Determinations of Static and Impact Loads Transmitted to Culverts." The bulletin is the result of a 3-year highway research investigation conducted at Ames, Iowa, in cooperation with the United States Bureau of Public Roads.

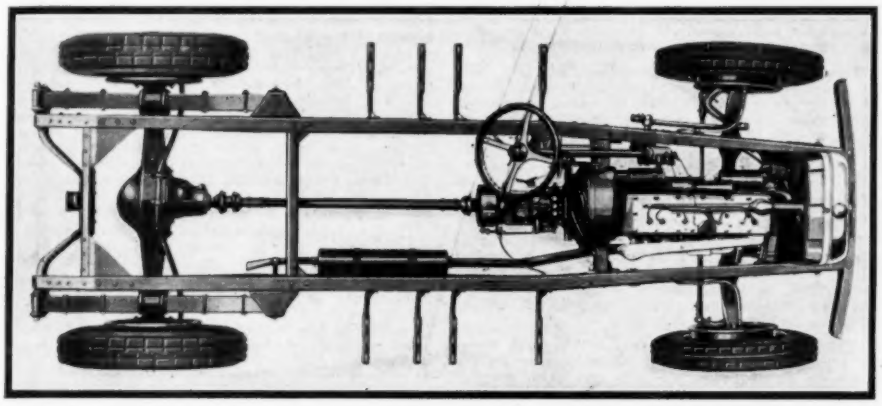
The Hug Ready Mix Concrete Rear Bottom Dump Body

Graham Brothers Announce New Line of Fast Trucks

Graham Brothers, the truck division of Dodge Brothers, Inc., introduces a complete new line of trucks, the feature of which is a fast and powerful six cylinder two-ton chassis available in three types.

Introduction of the six cylinder 2-ton truck and improvements in the present line of fours in ¾, 1 and 1½-ton, slight changes to adapt this engine to truck service.

A heavy duty transmission with four speeds forward and one reverse contributes to this truck's ability to perform under difficult road conditions. The first speed ratio is 6½ to 1, resulting in approximately 60 per cent increase in pulling ability compared with the first gear position of the three speed transmission formerly used on two ton models.



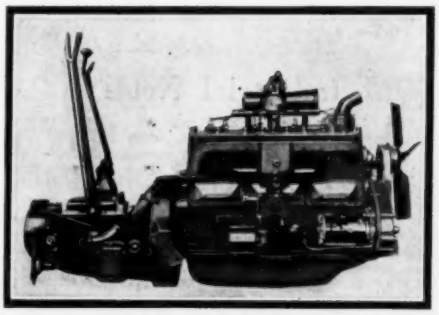
General View of the Chassis of the New Trucks. This 114-in. Wheelbase Model Is Specially Designed for the Roadbuilder

capacities constitute a step forward in truck design which should aid materially in speeding up road work and lowering hauling costs. The quick acceleration and braking and the fast economical service on the open road of these new trucks is comparable to that of the passenger car, say the manufacturers. A four forward speed transmission in the new 2-ton chassis assures surplus pulling ability for emergencies and makes possible moderate engine speed for fast, long runs. The recently introduced new four cylinder engine in the lighter capacity models also has the advantage of moderate speed in fast service. Thus speed and economy are both served.

Three features of the new six cylinder truck are particularly interesting and warrant description. They are the engine, the four speed heavy duty transmission, and the four-wheel hydraulic brakes.

The design of the six cylinder engine is inherently consistent with the makers' reputation. The 7-bearing crankshaft alone is an interesting feature for the rugged service demanded in motor truck operation. It weighs 69 pounds and is machined all over. The connecting rods of chrome-vanadium steel and pistons of light alloy give the strength and snap desired in the modern motor truck. Modifications in the manifolding, elimination of the thermostatic control and the intake heat regulator controlled from the driver's seat, which are used in the Dodge Brothers six cylinder passenger car, together with the use of a special carburetor jet and a special truck type fan, have been

Lockheed hydraulic four wheel internal expanding brakes built for heavy service provide quick and positive braking and make this truck particularly easy to control. These brakes are automatically equalized, largely eliminating the necessity of making even the simple mechanical adjustment provided for each individual brake. An automatic supply tank is directly incorporated into the unit containing the



The Power Plant Is Designed Along Modern Lines

master cylinder so that the system is kept full at all times.

In addition to the hydraulic brakes the hand lever operates a propeller shaft brake so that a positive mechanical locking brake is provided for use when the truck is parked.

Another important feature of these six cylinder trucks is that they can be had with various axle gear ratios which are optional with the purchaser. The axle gear ratio represents the number of revolutions of the engine crankshaft corresponding to one revolution of the rear wheels in high gear. The axle is furnished in three ratios—5.1 to 1, 5.667 to 1 and 6.375 to 1, the first giving the fastest vehicle and the last the slowest for the same engine speed.

25th Anniversary of American Road Builders' Association

This year brings the 25th anniversary of the American Road Builders' Association. The association was organized to acquire and disseminate information covering the construction and operation of highways and to stimulate interest and promote educational and legislative measures.

Created by five enthusiastic good roads boosters the organization plodded on setting forth the demand for good roads and telling how to get them.

The early life of the association was spent in distributing good roads propaganda. Conventions were held, enthusiastic but small, to grow in size and to increase in educational value; later these conventions were augmented with equipment expositions and from these grew the Road Show.

This small body of organizers spread the gospel of good roads throughout the land and did it so thoroughly that the movement grew in leaps and bounds. Today the prosperity and progress of all communities may be measured by its roads. There are 23,000,000 autos that are daily making use of 3,000,000 miles of the roads, one-sixth of which are well-improved and form the medium of communication between the various points of the Union. No one denies that a good share of the incentive that has given us good roads was the result of the early efforts and good roads propaganda of the American Road Builders' Association; this association was quick to see the necessity of good roads and at the yearly conventions and road shows pointed the way to get them.

Small at first, but early to take the lead as a good roads association, keen to exhibit the benefits of good roads, the organization can feel proud of its distinction as the association that represents the highway industry—the constructor, the operator, the user of the road.

The American Road Builders' Association is not organized for profit, nor does it care to carry more than a justified business balance in the treasury, but it is concerned in its value as a medium of rendering service in the highway field, both to the industry and to the user of the highway.

Automatic Stop and Go Signal on Rural Highway.—Racine County, Wisconsin, has installed automatic stop and go lights at the intersection of U. S. Highway No. 41 and State Trunk Highway No. 20.

New Trade Publications

Calcium Chloride.—The Carbondale Calcium Company, in an illustrated letter recently mailed to highway builders, gives interesting data on the use of their 73 to 75 per cent New Process Granulated Calcium Chloride in curing concrete. Reduction of curing time, increased strength, and the proportions needed in cold weather are shown. Lower costs on roadwork are claimed. One useful table shows the quantity needed for curing a mile of concrete road of various widths. This company supplies the chemical in bags and in drums, and has developed a handy spreader for use on the job.

Cement Data.—The North American Cement Corporation, Albany, N. Y., has published a copyrighted wall chart, entitled "Reference Tables for Mortar," that gives interesting information relative to quantities of materials required in masonry work. One table gives weights of various building materials and soil. The chart is mounted on stiff board and provided with an eyelet in order that it may be kept hung on a nail in the job office.

Paving Brick.—The National Paving Brick Manufacturers Association, in their consolidated report for the month of July, show 79,954,000 No. 1 brick in stock at the beginning of the month, a production for the month of 26,488,000, shipments of 28,643,000 brick, and a total stock on hand at the end of the month of 77,799,000. Unfilled orders on hand at the beginning of the month called for 76,002,000 brick, while orders for 22,409,000 brick were received during the month, and unfilled orders on hand at the end of the month called for 67,465,000 brick. The report, showing a production of 82 per cent of normal monthly capacity, covered reports from 22 plants, or 57 per cent of the normal tonnage capacity of the industry.

Rollers, Steam and Motor.—The Buffalo-Springfield Roller Co., Springfield, Ohio, has recently issued a new catalog illustrating their wide line of Buffalo-Springfield and Kelly-Springfield rollers, with a general description of these machines. Both steam and motor driven rollers are shown, including a line of motor driven tandems. All machines comply with modern requirements, and contain features of design that are quite worth while. Pressure scarifiers that can be mounted on any roller are featured in the catalog.

Rollers, Motor.—The Galion Iron Works & Mfg. Co., Galion, Ohio, have recently sent out an illustrated letter describing their motor rollers. The Galion Master Four-Cylinder Motor Roller, a three-wheel outfit, is featured. Tandem rollers, International rollers, and E-Z Lift graders are also illustrated. A handy form is included for use in seeking further information regarding these and other products of the company.

Pumps, Diaphragm.—The Novo Engine Company, Lansing, Michigan, in a recent folder, describes the 61-O Novo Diaphragm pump and tells how it can well handle pumping work at a rate of 50 to 10,000 gallons per hour at a low cost. This pump is now equipped with the new vibrationless 2-cylinder Novo Roller engine, and is said to give long life and satisfactory service.

Pumps, Pressure.—The Novo Engine Company, Lansing, Michigan, in another folder recently issued, describes a new series of "Flud Oild" pressure pumps. One model, a triplex pump designed to serve a 27-E paver, is designed to deliver up to 110 gallons per minute at any pressure up to 500 lbs. It runs at a speed of 200 r.p.m., powered with a Novo 4-cylinder engine, every working part is enclosed and runs in an oil bath by means of their new "Flud Oild" system, and other interesting features are to be observed. This pump is reputed to deliver the required flow of water at the desired pressure, continuously, to distances as high as ten miles. A duplex and a single cylinder pump are also included in the line.

Hoists; Steam, Electric, Gasoline.—The National Hoisting Engine Company, Harrison, N. J., has issued a new catalog that includes bulletins giving complete specifications on their comprehensive line of steam, electric, and gasoline engine powered hoists. Machines suitable for all types of construction hoisting are shown. The line includes an electric car puller.

Concrete, Light Weight.—The Novocrete Company of America, Inc., 522 Fifth Avenue, New York City, has issued an interesting booklet telling of the properties of their light weight concrete known as Novocrete. This is a concrete mixed with a quantity of mineralized sawdust. It can be placed by tamping, by mechanical pressure, or by the cement gun. Handled just like ordinary concrete, it can be used in monolith, reinforced, or made into various concrete products. One advantage is the fact that such concrete is but half the weight of ordinary concrete. Good compressive strength and low absorption are claimed. It is reputed to give soundproof partitions and to be entirely suitable for both exterior and interior use wherever the dead load of a structure must be reduced. It can be sawn, nailed, screwed, polished, and colored. The chemicals used in treating the sawdust aggregate are said to have no bad effect upon steel. Reinforcing bond is said to be good. Interesting tests made at Columbia University and in other laboratories are abstracted. The company claims that the holding power of nails in this material is greater than in yellow pine. Licenses for the use of the Novocrete patents are granted to manufacturers of concrete products.

Stone Cutters' Equipment.—The Dallett Co., 165-189 W. Clearfield St., Philadelphia, has published a new series of leaflets describing their various products of interest to the cut stone trade. Drills, special tools, lettering equipment, pneumatic tools, polishing equipment, sand blast equipment, and safety devices are listed.

Dump Bodies and Hoists.—The Heil Co., Milwaukee, Wisc., has issued an interesting folder showing the mechanical and operating details of their twin cylinder hydraulic hoist used in connection with their dump bodies for mounting on any truck chassis. Heil dump bodies and hoists enjoy a good reputation. This folder helps explain why. Ask for bulletin 160. Bulletin 178 tells more about dump bodies that are available.

Weighing Hoppers.—The Butler Bin Company, Waukesha, Wisconsin, have just issued bulletin No. 150 under the title of Butler Weighing Hoppers. This is a 12-page bulletin profusely illustrated, and describes in detail the method of proportioning aggregates by weight. Copies may be had on request.

Electric Control Equipment.—"Edmoore" Power Demand Limitator, a patented product is the heading on Bulletin No. 11, published by Edward T. Moore, manufacturer, 500 Cahill Bldg., Syracuse, New York. The "Limitator" is an electrical device for automatically controlling and limiting the power demands or peak loads on electric power systems for consumers. It is claimed that by its use many small plants are saving large sums every month. The device is generally connected to the main incoming power lines of a consumer's plant so as to summate all power. The Limitator is in quite general use throughout the country and it is reported that small consumers of electricity are saving about $1,000 per year. For larger power users the savings are proportionately greater, so that in at least one instance,—that of a large industry in Ohio, the power saving is over $50,000 per year. It is understood that in one large city, Limitators control over 30 per cent of the total load of the Power Company and thus materially reduce operating cost for the central station. For this reason, the Power Companies are encouraging the use of Limitators and in some instances are ordering for their customers. The Limitator will control all types of load, such as motors in various industries. The Bulletin is profusely illustrated.

Industrial Notes

The Stockholders' Meeting of The Brown Hoisting Machinery Company was held at the company's office Monday, September 26th, and the stockholders without any dissent approved the merger and consolidation with the **Industrial Works** of Bay City, Michigan. A similar meeting was held by the stockholders of Industrial Works, who also approved the merger and consolidation. The union of these two companies will be effective about October 1st. The name of the new company is **Industrial Brownhoist Corporation.** It is organized under the laws of Ohio, with general offices at Cleveland. Mr. Alexander C. Brown is the president of the new company. The consolidated company will continue the manufacture of material handling machinery, operating its plants at Cleveland, Ohio, Bay City, Michigan and Elyria, Ohio. The new company, **Industrial Brownhoist Corporation,** will have assets totalling about fourteen million dollars.

The Robert W. Hunt Company, engineers, inspection and tests, Chicago, wish to announce that the location of their Birmingham office is now in the Bankers Bond Building, Birmingham, Alabama.

The National Steel Fabric Company, Pittsburgh, Pa., at a recent meeting of the sales organization, E. L. Benedict, vice-president, announced the following appointments, effective as of July 1, 1927. Robert L. Glose, formerly sales agent for the company was made sales manager. Charles C. Mercer, formerly sales counsel, was made advertising manager. William H. Shaffer, Jr., will continue as dealer sales manager.

The Trackson Company, 533 Clinton Street, Milwaukee, Wis., announces the appointment of two new distributors for its machines, Trackson Full-Crawlers for the Fordson tractor. The Tractor Equipment Company, 701 S. Broadway, Denver, Colo., is the new distributor for the Denver territory, and the Louisville territory will be handled by the Monarch Auto Company, Louisville, Ky. Both companies will carry the standard Model F and the Heavy-duty Model D Trackson Full-Crawlers, and repair and replacement parts. Service is an important policy with both these distributors, and Ford dealers in the territories will be assured henceforth of prompt and efficient attention to orders for parts, etc. The Trackson Full-Crawler converts the Fordson into either a 2-ton or a 3-ton crawler tractor, depending on whether the standard Model F or the Model D heavy-duty Trackson is mounted on the tractor. The Trackson-Fordson is claimed to be an efficient and economical outfit for road construction and maintenance, snow removal, etc., and to have plenty of power and traction to handle one-man graders, wheel and trail graders, patrols, drags, etc., and such snow plows as the Sargent and others. The heavy-duty Model D Trackson-Fordson handles larger and heavier road machines, with blades of from 7 to 10 feet, and is also adapted to use with diggers, hoists, loaders, and such snow plows as the Sargent new all-steel construction heavy-duty plow. The latter is especially designed for mounting on the Model D Trackson-Fordson. The Trackson Company will send literature on request.

C. G. McDonough was appointed director of sales of the **Selden Truck Corporation** at a recent meeting of the officers of the company. He goes to his new work from the Kelly Springfield Truck & Bus Corp. of Springfield, Ohio, where he held the position of sales manager. Previous to his connection in Springfield he was sales manager of the Commercial car department of the Willys-Overland Company, Toledo, Ohio. Increased production and new merchandising plans of the Selden Company throughout the country go into effect immediately as well as plans for increasing the dealer organization. Further announcements of additional appointments in the sales department will be made within a short time according to reports from Rochester.

F. M. Young, president of the Young Radiator Company of Racine, Wis., makers of radiators, cooling systems and heating units, has announced the appointment of John J. Hilt as sales manager. Mr. Hill has been associated with Mr. Young since 1919—for three and a half years at the Racine Radiator Company, when Mr. Young was vice-president and general manager of that concern, and previously for four and a half years at the Perfex Radiator plant. By virtue of his experience in this field, Mr. Hilt is well qualified for his new duties, which have to do with the manufacture and sales of heavy duty industrial type radiators for taxicabs, bus, truck, tractor and power units of various types. In the same statement Mr. Young announced that he has acquired the services of three other department heads who served with him at the Racine Radiator Company. D. A. Hisey, former superintendent and plant manager, who has been associated with Mr. Young the past six years, has become superintendent of the Young company, in charge of production. W. C. Klespe, formerly in charge of engineering at the Racine Radiator Company, is now engineer in charge of machinery design, radiator and tool layout at the Young factory. Christ R. Trumm, formerly in charge of the tool department and machine manufacture, another associate of Mr. Young for years, has been placed in charge of the tool room and machine production work for the Young company. Mr. Trumm has to do with the placing and purchasing of machinery equipment and he has set up an extensive battery of modern machines for the production of tools and dies used in the manufacture of radiators and in machine shop production work. In transferring their activities, the new department chiefs were accompanied by many of their former aides and co-workers, with the result the Young Radiator Company has an experienced and thoroughly competent personnel in every branch of production.

The Alexander Milburn Company, 1416-1428 West Baltimore Street, Baltimore, Maryland, manufacturers of welding and cutting apparatus, portable carbide lights, oil burners and preheaters, and paint and lacquer spraying equipment has organized an office in Boston to be known as The Alexander Milburn Sales Company, Wiggin Terminals Building, 50 Terminal Street, Boston, Mass. This office is under the supervision of Messrs. M. B. Crouse and G. B. Malone, both experienced executives in welding and cutting equipment. This office will handle the sale and distribution of Milburn equipment throughout the New England states in a highly specialized manner. The Alexander Milburn Company is enjoying a very good sale of its equipment in this territory as well as other parts of the United States and foreign countries.

Keeping the Roads Clear All Winter

Snow Removal Methods, Costs, and Equipment Reported From States Where the Snow Removal Problem Is Ever Present

The average automobile can safely negotiate roads covered by not more than 10 in. of snow, and can push through short distances of snow 12 in. in depth, since the current models of the average car have a road clearance of about 10 in. This depth of 10 in., however, exerts a strain on both car and driver. It is but logical, therefore, to say that snow removal is necessary in those states where the average winter brings snow depths approximating or exceeding these figures. This includes at least 36 states—those reported to be doing snow removal work during the past year.

Snowfall Records.—According to the U. S. Bureau of Public Roads, as reported in the August issue of Roads and Streets, more or less snow falls in all portions of the country with the exception of southern Florida, and the lower elevations in southwestern Arizona and southern California. The heaviest snowfall in the United States occurs on the west side of the Sierra Nevada and the Cascade Ranges in the states of Washington, Oregon and California, the average annual snowfall in this section being 300 in. or 25 ft. At one place in California, records over a period of years show an average annual snowfall of more than 65 ft. East of the Rocky Mountains, the regions of heaviest snowfall are the Upper Peninsula of Michigan and the Adirondack Mountains in New York, with an average annual snowfall ranging from 10 to 13 ft. In the central section of the Appalachian Mountains, including Western Maryland and portions of West Virginia, 7 to 9 ft. of snow, on the average, fall annually.

Expenditure for Snow Removal.—Further data contained in the January issue of Roads and Streets discloses that the 36 snow states, those states where the snow problem has been such that a definite snow removal program has been instituted, kept open about 92,756 miles of highway during the past winter, at an expense of about $4,000,000. These same states, during 1925, had 375,774 miles of surfaced rural roads, and 16,139,859 registered motor vehicles. From 1921 to 1925, inclusive, these states spent about three and one quarter billion dollars on highway improvement and maintenance. It has also been estimated that the people in these states, during 1925, invested about fourteen and one-half billion dollars on motor vehicles.

Snow Removal an Investment.—Lack of snow removal work in these states would result in roads being closed for as long as four months, or one-third of the year. This would therefore result in the tying up of a capital investment of $14,500,000,000 plus $3,250,000,000, or $17,750,000,000, for one-third of the year, equal to a none-use of about $5,916,600,000 per annum. This snow cost was practically saved by the expenditure on snow-removal of $4,000,000 per annum, or less than seven hundredths of one per cent of the investment that would otherwise be tied up. This cost of snow removal involved the expenditure of an average of only about $45 per mile per year. Costs in some districts run far higher, and in others far lower than the amount depending upon the extent of the snowfall and the method used in drift prevention and snow removal. An even greater extension of the snow removal campaign would seem eminently justified.

Why Remove the Snow?—The rural citizen has become familiar with living conditions in the city. He has developed a desire for fresh foods delivered from other markets and is no longer satisfied to spend the winter on those foods that he was able to store in his cellar during the harvest. He no longer is a self-contained unit, but relies upon the country merchant and the mail order house for his clothing, his tools, and the other things that he desires to purchase throughout the winter on his harvest earnings. He likes to drive into town occasionally with his family and attend a show after the buying is done, and does not propose to forego these pleasures during three or four months of the year. Without open roads he could not get to town. With open roads he steps into his comfortable closed car and goes and comes as he pleases, and his trade is of direct benefit to the man in town.

The country merchant no longer is satisfied to stock up his shelves for an entire winter, and to maintain extra storage space for the purpose. He would rather have his business in a more liquid condition and thereby increase his earnings. Without open roads he would have to stock up in the fall, investing his capital in goods that would not move for as long as four months. Without open roads his customers could not reach his store, and his trade would be materially reduced. With open roads he can replenish his stocks as frequently as can the city retailer. He can bring in an adequate supply of fresh meats, fresh fruits, and fresh vegetables for the sake of the rural customers who just as easily are able to come to his store as their needs require.

Without open roads, the postal service, medical aid, school service, fire protection, and so on are materialy interfered with. With open roads all these things can proceed without interruption.

The Closed Car.—This is the day of the closed car. With the open road and the closed car, winter driving is not only possible, but it is a pleasure. The additional money spent on closed cars as a result of snow removal from the highways brings further production and therefore further earnings to the automotive industry, and therefore to the rest of the country. No longer is the country snow bound for three or four months of the year.

The open road, secured at the ridiculously low costs involved, thus is a creator of wealth that can not be ignored. Snow removal is bound to continue, and even to increase, until no important road need remain blocked for as much as an hour at any time during the year.

The Municipal Problem.—The problem of snow removal in the city is of even greater importance. Such cities as New York and Chicago spend great sums of money every year to keep the streets and sidewalks open to traffic. Without snow removal the entire urban life would stop short at the first blizzard, and business would be at an end. Fire protection and police protection would become almost impossible, and the children could not get to school. A snow bound city is a city of great financial losses. Snow removal in any community is therefore a prime necessity. Owing to the conditions enforced by the very nature of any community the removal of snow is vastly more difficult and more expensive. Snow can not be simply piled to one side and left for the spring thaws. It must be removed entirely to vacant land or water courses often blocks or miles away. Thus the methods and equipment involved are not entirely the same as on the rural highway. It is entirely within the province of this article, however, to discuss both problems and their various solutions.

The Drift Problem.—By far the greatest trouble in maintaining open roads throughout the winter is experienced as a result of drifts. Snow drifts form in much the same manner as do sand-bars in a body of water. The drifting is caused by some obstruction that decreases the velocity of the wind or changes its direction in such a way that the larger wind-born particles of snow carried within 6 in. of the surface are deposited in the form of a drift. This phenomenon is particularly to be observed in level open country where each tree, each fencepost, each board or picket fence, and each hedge breaks the

Straight Blade Plows on FWD Trucks Widening Road in Wisconsin

force of the wind to such an extent that a drift is formed. These drifts form down wind in the direction of the prevailing winds, and in some parts of the country, as in Indiana, these drifts interfere for the most part with the north-south roads since the prevailing in that region are from the west or the north-west. Under such conditions all obstructions on the west side of the road, within 100 ft. of the highway, will give trouble, while obstructions on the east side of the road are of no great importance.

Drifts are particularly liable to form in cuts and on side-hill roads, while fills are ordinarily kept fairly clear by the winds unless their force is reduced by some wind-break. Bridge and culvert decks are often subject to drifting, because of the wind-break action of hand-rails or parapets. Some forms of guard rail cause drifts to form, while other types minimize this action.

Prevention of Drifts.—While in many places drifts are allowed to form and are then removed with more or less difficulty by the snow removal forces, it is more and more becoming recognized that it is more economical to prevent the drifts from forming wherever it is possible to do so. The snow removal work will then have to account only for the normal depth of snow involved, lighter equipment may be used, and the work will be done at greater speed and at lower cost.

In order to enter upon such a program, the first consideration encountered will be that of right-of-way. Since the worst drifts originate from causes within 100 ft. of the roadway, and a great majority originate within lesser distances, it is wise to control a right-of-way at least 200 ft. where possible. Thus measures may be taken to prevent drifts without interfering with property owners. Boards and picket fences will often need to be removed and wire fences substituted. Rail fences, stone fences, and hedges are other sources for trouble and must sometimes be likewise dealt with. Evergreen hedges or timber with undergrowth may be planted 100 ft. from the roadway to encourage drift formation where no damage will be done. A wide right-of-way simplifies these problems. On level ground, snow traps may be plowed in an adjacent field in order that drifts may be formed from the snow ridges left by this plowing, at a convenient distances from the roadway. This work is done with motor truck or tractor snow plows, plowing two or four of these furrows in the snow parallel to the roadway. This method is said to be quite effective as a snow fence and to cost less.

Snow Fences.—The use of special snow fence is becoming widespread. This is a form of fence that may be placed in such a manner as to prevent the formation of a drift on the roadway by causing it to form off to one side and at such a point that no expected extension of this drift will project into the roadway. This fence, in the desired length, may be placed on the right-of-way or on private property as required. Two forms of this fence, which is generally made of pickets connected with strands of wire, are used; a form designed to be put in place and remain there throughout its life, and a form that is put up in the fall, and then taken down and rolled up for storage in the spring. The portable form is the favorite, since it may be put on private ground during the winter when it will not interfere with the work of the proper owner, and taken down again in the spring when no longer needed and thus not interfere with growing crops and pasturage during the growing season. The portable fence, when rolled up in the spring, may be loaded on trucks and taken to storage, or it may be simply left in a fence corner or on the right-of-way until needed in the late fall. The latter practice is widespread since the fence needs but occasional overhauling and since haulage and storage costs are minimized.

Design of Snow Fence.—While there are several commercial designs of such fencing on the market, research on snow fence design is but beginning to reveal the points that must be known before the utmost efficiency and economy are to be secured. Current researches by the Michigan State Highway Commission indicate that the standard picket fence, 4 ft. high, with 1½-in. pickets spaced 1½ in. apart, is the most practical yet designed. Closer spacing of the pickets stops more snow, but the additional expense does not seem to be warranted, while wider spacing does not materially reduce wind velocity and leads to drifts that are too long. Higher fences lead to longer drifts, and it has been determined that it is better practice to use the 4 ft. fence, and then to splice on another 4 ft. lift as soon as the original 4 ft. height becomes buried by the snow. Thus the drift can be allowed to accumulate without extending itself beyond the desired normal limits.

"V" Type Plow Clearing Heavy Drift in Wisconsin

Another method is the use of fence posts high enough so that the fencing may be raised during the winter should an extension become necessary. While no data is yet available upon the proper distance that the snow fence should be placed from the road, this placement will depend upon the height of the fence, the character of the fence, the amount of snow that will accumulate during the season, the direction and force of prevailing winds, and the slope of the ground. A down slope will lengthen the drift, while an upward slope will shorten it. The proper use of snow fence, according to good authority, will reduce the cost of snow removal by 50 per cent in the heavy snow districts. This use of snow fence, removal of obstructions that create drifts on the highway, the use of snow traps in adjoining fields, and the use of other types of snow barriers that create drifts at such points that other drifts will not form on the roads, comprise the general preventative measures that have proved effective.

The New Rotary, Known as "Snogo," Widening a Blocked Highway After Making a Center Cut

Preventative Road Design. — Other preventative measures may be included in the design of the road itself. The practice of reducing grades by heavy cuts and fills ordinarily gives a road that is subject to heavy drifting, while the road that follows closely the natural terrain and is graded to about 18 in. above the level of the ground will generally be almost free from drifting. Fills are generally clear, especially if they are windswept, while cuts form good snow traps and are continually obstructed by drifts. Where a road may be given a high crown the center will tend to keep open with a minimum of maintenance even though snow will be retained on the shoulders. In heavy snowfall sections, cuts should be made as wide as necessary to provide storage of snow removed from the roadway during the winter. Where any considerable amount of snow is to be removed by truck, a roadway must be at least 30 ft. wide from shoulder to shoulder to provide storage space without interfering with traffic. Cuts must be wide enough for storage space off the roadway for another reason. Snow piled on the edge of the pavement will insulate the subgrade while the center will not be so protected. Frost action will then be non-uniform across the roadway, with deeper frosting at the center, and the spring thaws will result in considerable heaving that will do severe damage to the surfacing. Snow storage should be accomplished in such a way that spring thaws will not expose shoulders and embankments to excessive eroding action of the melting snow. Some engineers advoate the practice of keeping the ditches filled with snow to accomplish this purpose.

Snow Removal. — Snow removal on the rural road and snow removal on urban street and sidewalk are two different problems. In the country, the snow is removed from enough of the roadway to afford the required width clear for traffic, usually the entire width of the pavement, and this removed snow is disposed of by the same operation merely by pushing to the side in storage piles (in a cut) or by scattering to the side as far as the plow or blower can throw the snow, depending

Outfit on Street Work in Gardiner, Me. Model D Heavy Duty Trackson-Fordson-Sargent

Snow King Rotary Clearing Heavy Drift on Oregon Road

Meserve Rotary, Another Type of Plow

upon the type of equipment used. It is no longer the practice to use low speed plows that merely pile up a high bank of snow on the roadside. High speed equipment is used that spreads the snow over a greater area and thus makes a better job of removal. Drift prevention reduces the depth of snow that must be removed and thus makes this high speed equipment possible.

In the city, however, additional handling is required, since no portion of the street may be used for snow storage. This requires additional equipment and labor and snow removal is more expensive. Too, the work must proceed with greater speed since the demands of the situation are greater. The patrol system of continuous operation is preferred in many states as effective and economical.

Blade Plows.—While snows of less than 12 in. present little problem, depths of 12 to 20 in. are easily handled by a blade plow pushed by a 3 to 3½ ton motor truck, equipped with pneumatic tires. This provides an efficient plow of the displacement type for light duty at high speeds and leaves a clean surface. No rehandling is ordinarily necessary where the accumulation of snow at the sides is not too great. For ordinary conditions the standard blade height of 18 to 22 in. is satisfactory, but where the fall is heavier or where extremely low temperatures prevail a 12 in. extension often proves necessary. This one-way blade clears the road to its full width, moving the snow in but one direction. Thus, with an 8-ft. blade, only 2 trips are needed to clear a 16-ft. roadway. Often but little work is needed on the center of a road, since passing vehicles staying as they tend to do on the center of the roadway, pick up the snow as it falls and distribute it down wind. Thus the patrol needs but give attention to the edges when such conditions prevail. As soon as side accumulations become high, as often happens in regions where the annual snowfall exceeds 3 ft., the use of the blade plow becomes difficult, and the "V" type becomes necessary.

The "V" Type Plow.—Heavier snows are moved better by means of the "V" type plow pushed by means of a 6 cylinder, 3½ ton motor truck, likewise equipped with pneumatic tires for the sake of good traction. The plow should be so shaped that it will pick up the snow and roll it over to the side instead of merely pushing it aside. The patrol system is used with this equipment as well, operating at a speed of 20 to 25 miles per hour. When working at this speed, the plow will ordinarily throw the snow a distance of almost 40 ft. While this type will handle snow that is 3 ft. deep, it throws the snow to both sides and does not clear to the same width as a blade plow of the same clearance. A further disadvantage is that the "V" type blade will not give a level surface, and to counteract the bucking effect, a straight blade should be hung beneath the truck to clean up after the plow. A patrol equipped with both the "V" type plow and the blade plow can take care of any moderate snowfalls without recourse to further equipment, if adequate methods are utilized to minimize drifting.

For still deeper snows a heavy duty "V" plow, with elevating wings, and pushed by a 10-ton tractor of the crawler type, is often used. While this type will handle a 4-ft. snow, it operates at a slow speed, and leaves high side walls. It is therefore being abandoned by at least one state in favor of a different type of snow remover.

Rotary Plows.—At least three types of rotary plows are available for snow removal work, not counting the brush type of snow sweepers. The rotary plow is generally useful in handling the deeper snows and for widening after the "V" type plow. One type, recently developed, consists of a housing slung on the front of a truck, containing a pair of horizontal screws rotating to convey the snow to a common center, where it is picked up by a blower and blown through a discharge pipe to either side of the road, distributing the snow well away from the roadway. Like other snow removal equipment it is mounted on a truck of at least 3½ tons, equipped with pneumatic tires.

Another machine, the heavy duty axial type rotary, is said to be very efficient in deep snow as long as it is dry. Wet snow is said to clog the rotors to an undesirable extent. Mounted on a heavy duty tractor, this machine is equipped with a separate motor in order that the full tractor power may be available in bucking heavy drifts without depriving the rotors of the power needed for cutting into the drifts. This outfit, which is expensive, is said to be economical only where the annual fall exceeds 120 to 130 in. and where preventative measures cannot control the drifts to allow lighter equipment to be used.

A third type of machine, the pusher rotary, is a combination push plow and rotary. The rotors are mounted at right angles to the road. These rotors are intended to relieve the side pressures on the "V" plow and then throw the snow to one side. The side rotors

Sweeper Built by Cummings Car & Coach Co., with Special Rear Cab and Controls Used During Operation. Sweeping Done with Truck in Reverse and Driver in Rear Cab.

are also useful in cutting down high side banks. The pusher rotary can handle snow up to 8 ft. in depth, or to the tops of the rotors, although at these extreme depths the progress is slow. An adaptation of this machine, being adopted as standard by the Michigan State Highway Department, includes the use of a blade, tilted about 30 deg. from the vertical, mounted behind the tractor. This blade breaks down the side banks, pulling the snow into the road, and permits breaking down banks that are higher than the rotors. On a return trip, this snow is picked up by the rotors and thrown over the bank.

Rotary Sweepers.—Light snows can be removed by means of a rotary broom attached to the front or rear of an enclosed truck. One model is mounted on the rear, and the truck is driven in reverse during the sweeping action. For this purpose a rear cab, with separate driving seat, steering gear, and controls, is furnished. The use of the rotary broom, long successfully used on steam and electric railways, should prove useful on the highway since the scattering action of the broom is good, the surface is left in a smooth condition, high speed operation is possible, and the same outfit might even be used in a modified form for street cleaning in the summer.

Municipal Equipment.—Snow removal work in the city requires the rapid initial opening of traffic routes, the temporary formation of small storage piles, and the immediately subsequent removal of the snow to vacant lots or to the municipal dumping ground. While the actual clearing of the street is done with much the same equipment as is used on rural highways, with blades and "V" type plows mounted on truck or tractor preferred, additional equipment is needed. Motor trucks, or sometimes dump wagons with 2-up teams or 3-up teams, are used to transport the snow to the disposal point. Loading from the storage piles is accomplished by crews of shovelers recruited from the ranks of the unemployed, or by means of snow loaders of the bucket elevator type, or by means of belt conveyors, or by means of small power shovels, or by means of small clamshell cranes mounted on truck or tractor. Tractor-operated power loaders or the scoop type are sometimes used. The street cleaning gang, with its ordinary hand tools, can aid in the work and do the clean-up work after the major equipment. This force, can, at the same time, remove the snow from the sidewalks and push it into the storage piles. Wheel scrapers and fresnos, with 2-up teams, often prove useful in building up the storage piles and cleaning up the remnants of storage piles after the other equipment, building up final storage piles for the sake of easier handling.

Handling Heavy Drifts.—In mountainous regions, heavy drifts and slides that cannot be handled with ordinary equipment frequently block a road for some time. Often alternate freezing and thawing builds up a series of layers of about the consistency of soft stratified rock. These accumulations may sometimes be opened for plowing by means of a judicious use of blasting powder or dynamite. The charges and spacing of charges will be about the same as with laminated limestone. Holes are first sunk with a pole, and then the charges are placed and fired

A Haiss Snow Loader Cleaning Up After the Plows, Loading the Snow Into Dump Trucks

in the usual manner, using an electric circuit with a blasting machine, or blasting fuse. Black powder is effective in a dry snowbank, while wet snow requires dynamite. Since conditions will vary greatly, no fixed rules for carrying on this work can be laid down. An interesting job of this kind was done during 1925 when 8 tons of explosives were used in opening up 2 miles of road in the Berthoud Pass in Colorado prior to the use of rotary plow. While not always successful, this idea is worth knowing about.

The Pennsylvania Plan.—About one-half the mileage of roads in the state of Pennsylvania, a total of 6,340 miles, comprising all principal routes, are included in the snow removal system. The policy is to keep this mileage always open to traffic. Additional roads are kept open as far as possible. About 1,500,000 ft. of snow fence is in place. The system is organized into 52 maintenance districts, and four wheel drive truck as well as tractor equipment, with blade plows, "V" type plows, and rotaries, are kept in readiness in heated garages in these districts. A snow alarm system is used, and thousands of men are called into service when a storm breaks. Snow is removed from the entire road surface and from an 18-in. strip on either side, the work beginning as soon as the snow has reached a depth of 2 in. Hills that become slippery are covered with a scattering of stone chips or cinders. In this way the main roads of the state are kept always open and in a normally safe condition for the winter traffic.

Wisconsin Work.—In northern Wisconsin the snow removal plan is complicated by the fact that considerable logging is done in the winter, and about 6 in. of snow must be left on the roads to accommodate sleigh traffic. This makes the work of plowing more difficult than usual, and yet the main roads of the state are kept open for automobile traffic as well. During the season of 1925-6 about 1,500 miles of road were included in the snow removal program, at a cost of about $100,000. Sixty miles of snow fence were placed during that season. Last season the appropriation was raised to $250,000, about 275 miles of snow fence was erected, and additional equipment was purchased for snow removal.

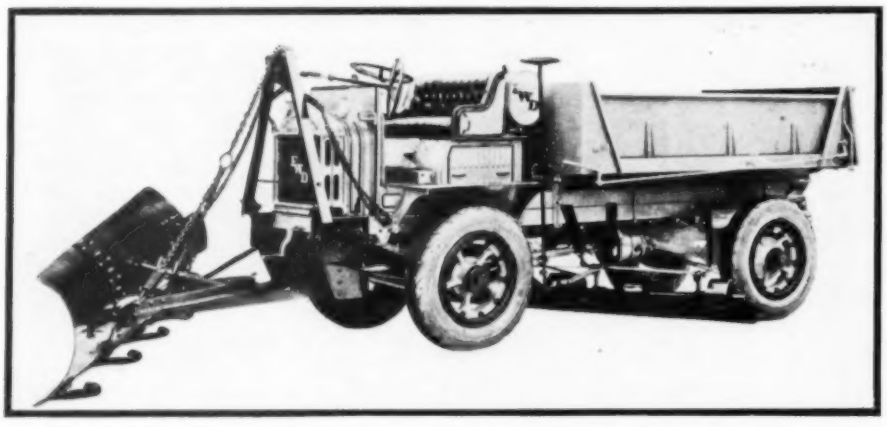
Michigan Methods.—According to the July, 1927, issue of Roads and Streets, the state of Michigan included 5,704.7 miles of road in its snow removal program last winter, at a cost of $302,474 or $53.02 per mile. In some counties the fact that bus routes were cleared in part by the bus companies involved lowered the snow removal cost to the state. The cost was found to be lower in those counties that had adopted the continuous system of truck patrol, reserving the heavier equipment for widening work and for occasional emergencies. New methods resulted in a better and smoother snow surface that permitted comfortable driving at summer speeds. Several new methods were developed in one division. Snow traps were plowed in cultivated fields as a substitute for snow fence. The use of a spring blade behind a "V" plow, and the blade behind the rotary plow to pull down high banks were other new developments of the season in the same division. These three methods have already been described in this article. Further methods are being studied, and a better standardize procedure should reduce costs materially.

Wayne County, Indiana.—This typically rural county, containing one important city, has materially reduced its snow removal costs by means of the elimination of old fashioned methods and the adoption of modern machinery. Snow fence is an important part of the program. Drift-forming trees are trimmed of their lower branches, brush and weeds are cut when found to throw

drifts on the road. Offending fences and other structures are removed or replaced by non-drift-forming ones where possible. The greater part of the snow removal is done with the ordinary horse or tractor-drawn grader, while heavier work and trimming are done with "V" type plows pushed by a motor truck or tractor. Rotary sweepers have been used with some success. The center of the road is first opened with due speed and kept open, and next the snow on the sides of the road is thrown entirely off the pavement and shoulders and into the ditches and to the far side of them. Thus a maximum width is maintained for traffic as far as possible.

Modern Equipment in Boston.—The snow removal work done by the Public Works Department of Boston discloses the use of all sorts of modern equipment. The downtown section of the city is divided into 15 plowing districts, consisting of 44 plowing routes, each district in charge of an inspector. At the beginning of a storm, each driver is given a ticket with the names of the streets he must plow. He remains on the street during the entire storm, obtaining gas and oil from a 500 gallon supply truck that makes the rounds of the work. After the storm, a force of 20 emergency men load the snow into trucks for disposal. The equipment of this part of the city, purchased last year, includes 20 Mack, 20 White, 11 American LaFrance, and 10 G.M.C. trucks equipped with Champion and Baker blade plows. Nine Pierce Arrow trucks are used to haul the snow to the dumps. Then there are three Mead-Morrison tractors equipped with Walsh "V" plows, two Caterpillar tractors (Holt and Best) with Sargent plows, one Monarch tractor with a Champion blade plow, six Barber-Green and two Nelson snow loaders, two Fordsons, a Mack wrecker that is a repair shop on wheels, and a Reo truck to transport the men. Most of this equipment is used in the downtown section. Last winter 30 trucks with blade plows were hired from contractors to first open main trunk lines in outlying sections and then to plow the side streets. The city trucks are used by the sanitary service during the day when they are not on snow work. Every night 15 trucks are equipped with snow plows which are then removed in the morning if the trucks are not needed for plowing. Saturday nights and nights before a holiday 30 such trucks are equipped in readiness for an emergency. Because of the continuous plowing service now in force very little picking is needed after a storm and the streets are found in better condition in the spring. Hand labor during a storm has been greatly reduced.

What Manufacturers Are Doing.—Without modern labor saving equipment this snow removal work could not be accomplished. So rapidly has snow removal grown in use during the past few years that much new equipment and many improved devices are being perfected season by season. The following devices and performance, reported by the manufacturers, are indicative of the advances that are being made. No doubt others equally interesting could be found should space permit their mention.



FWD Truck Equipped with Curved Blade Plow and Scraper Blade for Patrol Work

FWD with Curved-Blade Plow.—The curved-blade one-way snow plow, when used in connection with the FWD truck is capable of removing snow from highways at a normal speed, for the blade is high enough so that the snow reaches the plow before it reaches the top. The blade is set at an angle, and cuts a lane approximately ten feet wide, depending on adjustment and operating conditions. As the snow piles up on the edge of the road, the wing on the wide of the plow forces the snow out even farther so that a second cut can be made without difficulty. Two tons of ballast are usually carried on the truck.

The blade of this plow is made of ⅜ in. sheet steel stock, 14 ft. long, 26 in. wide on the inside end and 40½ in. wide on the outside end. The wing or extension gives an extra length of 3 ft. The plow may be elevated with a hand wheel, to clear the road when moving from one location to another. The blade may be set at an angle by means of adjusting pins in the circle. A spring allows the blade to release when it strikes an obstruction, and then returns the blade immediately to its cutting position. The entire plow weighs 1,979 pounds.

Due to the contour of this plow it rolls the snow and when traveling at a fair rate of speed will throw it clear of the road. In heavy going the plow does especially good work in widening the road after a V has opened the way. Because of its width, it is used to best advantage where the traffic is not heavy.

Straight Blade Snow Plows with FWD Trucks.—The straight blade snow plow consists of a steel scraper blade 10 ft. long, by 20 in. wide, which may be raised or lowered by means of a reel operated from the driver's seat. This blade is usually hung to a semi-circular steel frame, which provides for angular adjustment, making it possible to set the blade for either right or left hand cutting, or in fact, any desired angle. This adjustment permits the blade to be used for plowing the snow toward the gutter or toward the center of the street, or to be used as a pusher for moving piles of snow to manholes or dumps. When the operator wants to change the angle of the scraper blade, it is only necessary for him to remove the pin that engages in a series of holes in the semi-circular frame. When the blade has been set at the desired angle, the pin is inserted and the blade is held rigidly in position. A tilting device is also provided, so that the blade may be tilted backward or forward, to meet the existing snow conditions.

The blade or mold board is made of ⅛ in. carbon steel and is 10 ft. long by 17½ in. wide. To this mold board is attached a cutting edge 10 ft. long by 6 in. wide, made of the same material. This cutting edge is detachable so that it can be easily replaced when worn out. When the blade strikes obstructions, such as manhole covers and car tracks, the blade is released automatically and, after passing over these obstructions, returns to its operating position.

The vertical movement of the scraper blade is controlled by means of a large wheel at the driver's seat. The man who manipulates the plow sits with the operator of the truck and, by means of a hand wheel operating in connection with the worm gear, easily and quickly adjusts the scraper blade to any working condition. The lifting device is a universal attachment so constructed as to be adjustable and quickly attached. The top of this device consists of a worm gear housing fastened to the side members. Attached to this casting and also to the side members are two adjustable angle supports. These angles are used for supporting the lifting device in a vertical position by means of chain braces fastened to the truck frame. The casting at the top of the attachment supports the worm gear which is used for raising and lowering

the blade. The gear is cast integral with a drum over which winds the chain for vertical adjustment of the blade. The design is such as to make a very easy and effective blade lift.

The plow, throughout, is made of very best materials; the wearing parts are of a high carbon steel; the connections to the truck are of forged and structural steel; the few castings that are used are made of highest grade.

Graders Serve as Snow Plows.—Motor patrol graders such as the McCormick-Deering E-Z Lift Motor Grader manufactured by the Galion Iron Works and Manufacturing Company, Galion, Ohio, often prove useful in snow removal work. The same concern, like other grader manufacturers, manufacture other models for use with other makes of tractors, as well as a line intended to be towed by tractor or truck, and a line to be drawn by horses. The model mentioned above is a one-man outfit useful for summer maintenance work as well as for snow removal work, and is of the type wherein the tractor is at the rear and pushes the grader itself. The adjustable blade is preceeded by a scarifier that helps break up packed snow and ice.

The Galion McCormick-Deering E-Z Lift Motor Grader That Serves Well Where Snows Are Not Too Deep

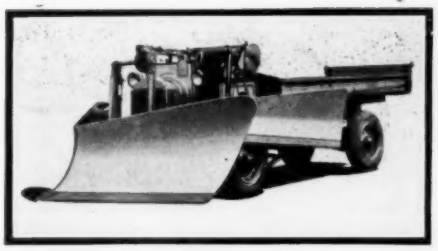
V Type Plows on FWD Truck.—The 'V' type plow is used very much for breaking the first road through the snow. The sharp nose of this plow permits working in very deep snow without much pressure being brought to bear on the plow. The action is that of raising and rolling—very similar to that of the farmers' field plow. The plow does not hit the snow head-on for the mold boards pass the snow from the road to the roadside.

The V plow, however, is also used for widening the road. In spite of the pressure being all on one side of the plow, according to the manufacturers, the FWD holds to the road and goes straight ahead almost with the same efficiency as when the pressure is equally divided. The traction on the front wheels of the FWD prevents the truck from lifting and swerving. When the bank is very high, the truck is driven at an angle; that is, the truck is pointed to the side of the road and driven slightly sidewise.

The plow is fastened to the truck by means of the hoisting frame supports which are mounted on the forward corners of the truck frame, and push frame brackets which are attached to the underside of the truck frame just to the rear of the seat. The front end of the push frame is rigidly fastened to the plow, and the rear end of the push frame is hinged to the brackets on the truck frame by means of a shaft which runs through the arms of the push frame and the push frame brackets.

The spread of the wings of the V type plow is 10 ft. 6 in. from tip to tip; the cutting edge width is 9 ft. 6 in.; the height of the front end is 2 ft. 9 in.; the height at the outer ends of the mold boards is 4 ft.; the mold boards and the bulk heads are built of 1 in. steel plate. All other parts of the plow are built of structural steel.

The maximum lift of the plow is 6 in. Two cables are fastened to the bulk head, and run from it to the hoisting shaft at the top of the hoisting frame, where they are wrapped around the hoisting shaft. This hoisting shaft is operated through a worm gear and worm wheel.



"V" Type Plow with Elevating Wings as Mounted on FWD Trucks

The advantage of the V plow is that when it is used with FWD trucks, a road can be plowed through deeper snow than can be handled by the smaller plows. When the snow has been allowed to pack into deep hard drifts, a V plow mounted on an FWD, or with FWD trucks in tandem back of it, will usually break a road through. Sometime the trucks are hitched together with a home-made hitch; but because this arrangement of having practically one unit under two separate controls requires exceedingly close cooperation between the drivers of the trucks, the hitch is being replaced by bumpers. When bumpers are used, the truck can be operated separately or together, as conditions require.

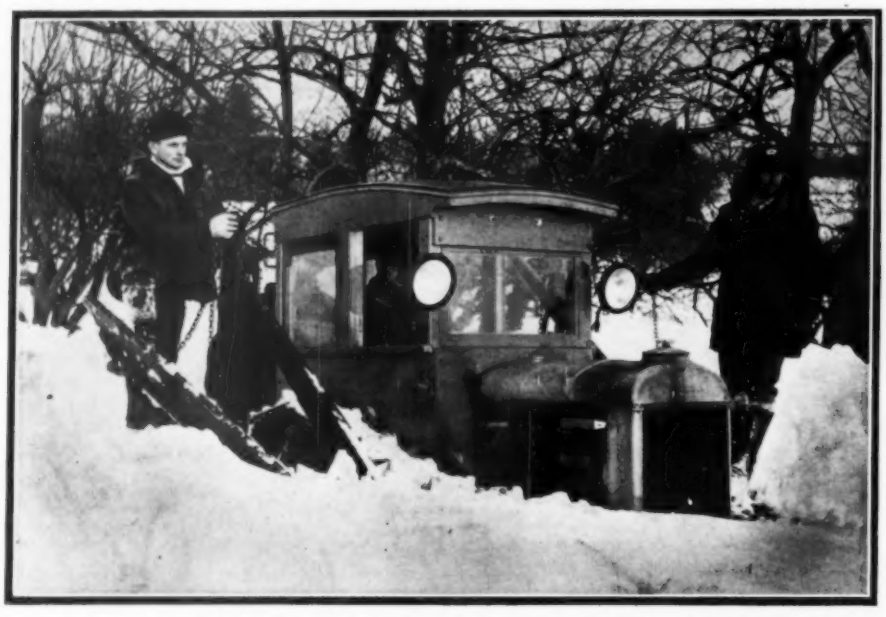
Because the V plow is used very much for breaking the first road through the drifts, it is built to withstand hard bucking. The impact is not centered on the frame work of the truck—it is transmitted along heavy rods to the middle of the truck through strong braces attached to the truck amidships. There is nothing flimsy about this outfit. It is built for snow removal work of the hardest kind.

The plow is carried by the truck. It does not have to be pushed along the ground, but rides entirely free of it—

"V" Type Plow on FWD Dump Truck in Wisconsin

no extra resistance for the truck to overcome; the power of the truck is all concentrated on the work of removing snow. There is no difficulty in handling this outfit at high speed, either, for, as you will notice in the picture, it is very compact.

There are certain conditions where both the V type plow and the straight blade plow can be used on different occasions; the V can be used for breaking through and the straight blade used for moving the banks left by the V plow, to the side of the road, or the straight blade only can be used when the snowfall has been light. With the mounting used on FWD trucks, either plow may be attached. The V plow or the straight blade type can be used without incurring difficulty or loss of time in making the change. It is only necessary to remove a few bolts, slip off one plow and replace it with the other. The same control is used for both types of plows.



Trackson-Fordson Outfit Pulling Through Heavy Drift on 100 Mile Patrol in New Hampshire

There are several types of V plows used on FWD trucks. Among them is the type that is equipped with wings. When this type of V plow is used with FWDs in tandem it is not only very successful in breaking through the deep drifts, but also clears a much wider road than does the ordinary plow.

The chief requirement of a snow plow unit is that it must have the ability to maintain high speed when the going is good, a fair rate of speed when conditions are average, and to make some progress under bad conditions, even if it has to back up frequently and buck the snow.

LaPlant-Choate Plows.—This firm, located in Cedar Rapids, Iowa, manufactured a line of blade and "V" type plows for use with Caterpillar tractors and motor trucks, both plows for patrol and for emergency drift service. The truck plows of both types are carried by the main frace of the truck or motor buss and are intended to operate at the normal speeds of the vehicle. These are typical patrol plows that contain worth-while features, such as an easy lift apparatus, and a safety trip that prevents wrecking the plow by striking an obstruction in the road. The plows for tractor service are quite interesting. For instance, the Tractor V Plow is mounted on a heavy frame swung on the sub-axle at the pivot center of the tractor. Thus the plow, carried entirely by the tractor, holds to the road regardless of the bucking motion of the tractor itself and will not dig its way out over a drift. One-man hydraulic control is another feature. With this control, mounted on a wide platform at the rear of the tractor, the plow operator easily controls the plow itself and the elevating wings which are each operated independent of the other. These may be used in such a way as to give sloping or vertical side banks, to roll the snow away from the plow to reduce tractive effort needed, to give a wider cut in light snow, or either may be instantly raised to allow traffic to pass. The entire plow is easily raised to pass obstructions or to allow progress at road speed over dry stretches. The "V" plow is shaped to lift and roll the snow instead of pushing it to one side. Adjustable large mushroom shoes prevent the mouldboard from digging into the road. No levers or jacks are used to operate the plow, and one driver and one plow operator constitute all the crew needed.

Simliar features are found on the blade plow, as well as on the small tractor-operated sidewalk plow included in the line.

Baker Plows for Patrol Work.—The Baker Mfg. Co., of Springfield, Ill., manufactures a line of blade and "V" type plows for attachment to motor trucks that are widely used in patrol work. These plows are attached to the front axle of the truck and are supported by a frame. A simple control mechanism, operated by a handwheel at the driver's seat, raises and lowers the plow as required. A safety feaure is incorporated in the blade to avoid breakage should an obstruction be encountered in the road. Renewable shoes keep the blade from cutting into the road surface. Another widely used plow is the Sargent, manufactured by the Union Iron Works, Inc., of Bangor, Me. Their "V" type plow is mounted on the front of a truck or tractor and is controlled by means of a handwheel, located at the drivers seat, a gear, and winch arrangement in the frame that supports the plow. A special nose plate carries the plow up over obstructions. Since this plow is also of the lift and roll type it is effective for patrol work.

Trackson-Fordson-Sargent Units. — Over 200 New England communities have found the way to the "open road" by using Fordsons with Trackson Full-Crawlers and Sargent snow plows to solve their snow removal problems. Three hundred and fifty of these units were delivered to the New England states in the fall of 1926 and last winter kept the highways open to motor travel in below zero weather and the worst snowstorms of the year.

Most of these outfits were purchased by highway officials of the counties, townships, villages, etc., and many of them replaced much larger tractor outfits which formerly were used but were found too expensive for the average run of snow removal work. The power and speed of the Fordson with Trackson Full-Crawlers enables this outfit to go through the drifts as effectively and at a faster rate of travel than the larger tractors, according to the manufacturers, and it costs a great deal less to maintain and operate.

Among the 350 Trackson-Fordson-Sargent units delivered to New England last year, were a number purchased by public service corporations. The Lovell Bus Lines at Maynard, Mass., operate three of these outfits to keep their routes open, and the Burlington Bus Company of Burlington, Vt., is able to put roads through where formerly 5 men and other equipment failed, it is claimed.

For most snow removal work the standard Model F Trackson-equipped Fordson with a plow like the Sargent has sufficient power and traction. For plowing under extremely difficult conditions, however, the Trackson Company produces a Model D heavy-duty crawler which converts the Fordson into a 3-ton outfit with a great reserve of rugged strength and power, which has greater crowding action at slower speeds than are possible with the standard Trackson. The new all-steel construction Sargent Plow which is manufactured

by the Union Iron Works at Bangor, Me., is especially adapted to mounting on the heavy-duty Trackson.

The City of Gardiner, Me., uses both a Model D Trackson unit and a Model F to keep the streets free from drifts.

Acme Fordson Snow Handler.—A Fordson unit that has proven effective is manufactured by the Acme Road Machinery Company, Frankfort, N. Y. It consists of a substantial frame carrying a "V" type plow and two elevating wings. The unit may be used on other light tractors as well. The frame relieves the tractor of the stresses attending snow plow operation, while the tractor itself supplies the motive power. An independent rear axle, mounted in Hyatt roller bearings, and geared to the power unit at a ratio of 3 to 1, permits a combination of large diameter wheels, good power, and a standard locking device by means of which both drive wheels may be locked to the rear axle for a combined pull when desired. The main blade, which lifts and rolls the snow, is attached underneath the main frame and held firmly in any desired position. It is easily adjusted by the operator and can be swung to an angle of 49 degrees either way with the line of direction. Side wings permit cutting down side banks, the building up of sloping banks, the throwing of snow first moved by the plow up over the bank, and plowing to greater widths in light snow. A scarifier can be attached to the rear of the tractor for breaking up rutted ice. This interesting one-man outfit can be equipped with roller wheels, rubber tired wheels, or crawlers with or without grousers.

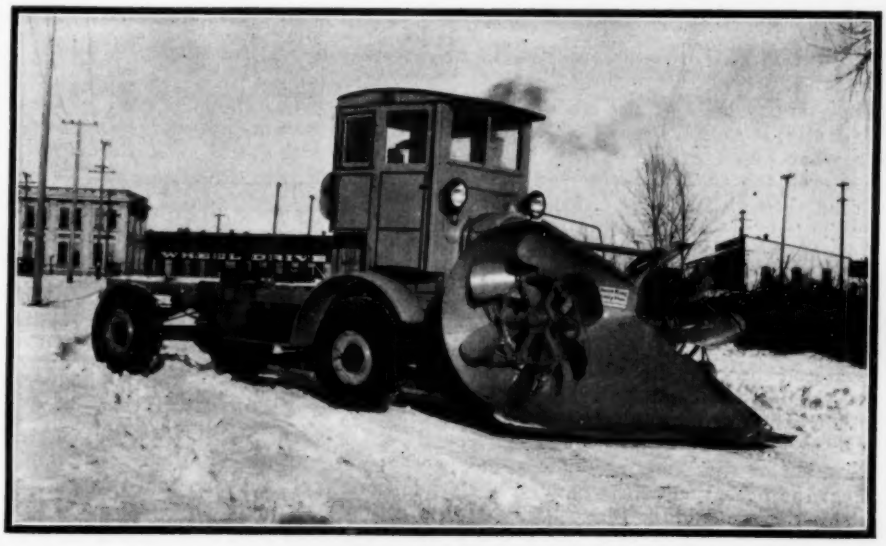
Rotary Plows with FWDs.—This lateral type rotary plow is designed for use with the four-wheel drive truck. It will clear a space about 8 ft. wide and is 4½ ft. high. It can be depended upon to work through drifts of its own height and in extreme cases even deeper snow can be cleared. In an ordinary depth of snow—8 and 10 in.—provided the snow is not heavy or frozen, this plow can be operated up to 12 miles per hour. The snow is thrown outward for a distance of anywhere from 10 to 40 feet. With it it is possible to remove the snow for the full width of the highway without creating any banks. It can be operated on one side only; so that in the event a push type plow has been used, it will be possible to use the rotary plow to cut down and remove the banks.

The plow can be adjusted to remove the snow to the surface of the road, or leave as much covering as is desired. It is provided with a roller type caster shoe, in order to transport the plow over bare sections without having to slide it. It is a one man outfit; the plow requires no attention in the way of adjustment after it has been set in working position.

The power is taken directly from the crank shaft of the motor of the truck. Universal joints are employed in order to give complete flexibility to the transmission line. The plow is attached to the frame of the truck in such a manner as to give complete freedom to the plow; no strain is therefore placed upon either the motor parts or the truck frame and the plow will oscillate independent of the propelling vehicle.

The transmission employed on the plow is the worm drive type, having a 5 to 1 reduction. The rotars which are 45 inches in diameter, consequently revolve at one-fifth of the motor speed, usually between 250 and 300 R. P. M.

The plow, being of the 'V' shaped type, enters the snow ahead of the rotars, thus breaking up the snow and delivering it to the rotars in such a manner as to make it easily expelled. The rotars being mounted on the outside ends of the mold boards, relieve all pressure, making it possible to operate a rotary plow of this size with the truck.



Snow King Rotary Plow on Motor Truck

The plow illustrated, which, complete with hitch, weighs about 2,000 pounds, is of the "snub nose" type, with specially designed wings so curved as to bring the snow to the rotary fans with the least amount of friction. The wings do not touch the ground, but are fastened to the top of the sliding shoes. They are said to be practically indestructible, being so shaped and braced that even the greatest pressure will not crack or break them.

The frame work supporting the wings is rugged. The best quality steel castings are employed. The sliding shoes are removable and can be replaced. The center brackets perform the double duty of bracing the wings and furnishing the fulcrum for the adjusting mechanism. Large set screws operated by hand wheels are provided to adjust the suction. The two outer braces on the wings and the cross brace at the top make the plow perfectly rigid. Return shoe plates are welded to each of the wings so that the plow can be pulled backward.

A caster wheel supports the plow and swings it clear of the surface when traveling over bare ground. This is a big saving on the wear of the sliding shoes and also aids in getting the plow in and out of buildings without damage to floors, etc. When the plow is at work the caster wheel swings suspended. It is raised and lowered, from outside the plow, by means of a crank.

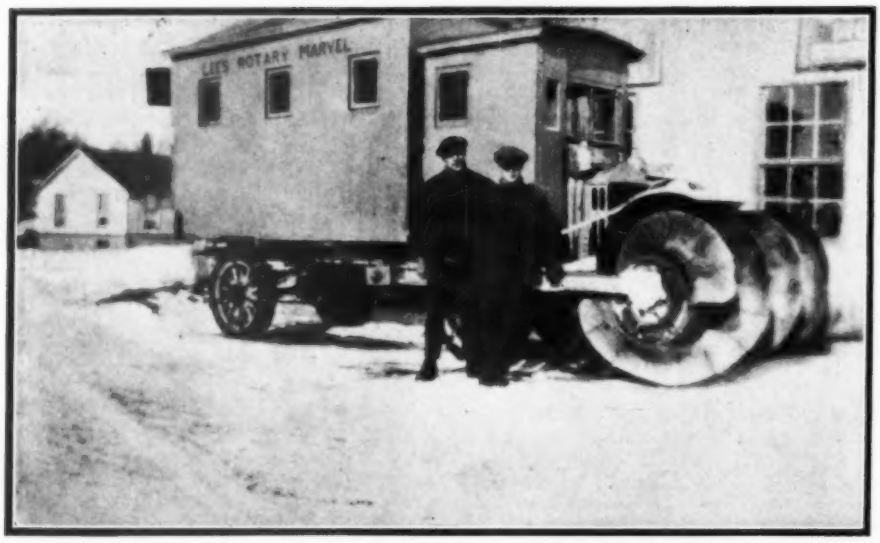
The rotars are of the "built up" type. A heavy steel hub supports the adapter or wheel proper. To this hub and wheel are fastened the fans that actually expel the snow.

The fans can be described as having a "bird wing" shape. They enter the snow without impact and so have no bad effect upon the motor parts. They are attached to the hub and wheel, and supported at six points. The entire construction is as rigid as though made of one piece.

The power for driving the rotars is taken from the motor of the propelling vehicle. It is transmitted by means of a shaft, attached to the crank shaft, through a universal joint, so designed that if the rotors should strike an immovable obstacle the outside connection would give, and no damage result to the motor. The power shaft is fitted with a pinion, revolving on a ring gear, which in turn drives the rotars by means of cross shafts. Everything is enclosed in a steel housing, and all working parts run in oil.

Lee's Rotary Marvel.—Last winter a new type of rotary snow plow was developed which will be used exclusively in conjunction with FWD trucks.

The front part of the plow is shaped on the order of a scoop shovel. As the thing is fed into the snow the snow slides up to a rotor which forces the snow into a chute and out to the side of the road or into a waiting truck. The rotor is operated by a separate



Lee's Rotary Marvel, a New Canadian Plow, Designed for Use with FWD Truck

motor on the body of the truck which, incidently, is an FWD motor. No matter what depth of snow may be encountered the snow remover will make a road through it. It is not necessary for the truck to separate the snow; the truck does not have to force its way through; the truck does not push the snow off the road, but it conveys it instead. The truck can be driven fast or slow as desired; when deep snow is encountered the truck may be driven just fast enough to keep a full load on the rotors, when the snow is not so deep the truck may be speeded up. The operation of the truck motor does not affect the operation of the plow.

The Meserve Rotary Plow.—The Meserve Rotary snow plow is operated on the same principle as the endless chain ditch diggers; but instead of dumping the snow into wagons or trucks, it loads it into a large box on the chassis. The truck is driven backward into the snow on city streets, the endless belt with boards placed perpendicularly on it, picks up the snow and carries it to the top of the big box where it is dropped in and packed. When the big body is filled, the truck is driven to the dumping ground with its big load of snow.

Snogo, a New Rotary.—A new departure in design and operating principle is observed in Snogo, a rotary recently announced by the Klauer Manufacturing Co., Dubuque, Iowa.

The operating principle of this machine consists of two cutting augers, 18 in. in diameter, made of tempered steel, 7 ft., 10 in. long each, set one directly above the other in a hood, in a transverse position to the road. Auger flights move the snow from both ends of the augers to the center. Directly back of these augers is placed a blower fan.

The machine is powered with a 6-cylinder, heavy duty, low speed, industrial type engine, developing 140 h.p., which also furnishes traction for the machine. The machine has eight forward speeds, ranging from one-half mile per hour, up. The power operation of the blower and augers is constant.

As the augers cut their own way into the snow, and in the natural forward propulsion of the machine, the snow is received by the blower and blown completely off the roadway, little power is required for traction. As the operating principle is not a push operation, traction requirement is necessary only to move the machine up to the snow to give the augers contact.

The machine takes an 8-ft. cut, and additional cuts may be taken in either direction and up to any width and all snow removed from the roadway, even beyond the shoulder, effecting untold savings in maintenance expense by the elimination of thawing, soaking and freezing effect on the road bed. Depth of snow is said to be no barrier as traction speed is simply reduced to a point where fan, or blower, handles the volume. More than four years of experiment, tests, and actual field work have perfected the machine to a point of extensive marketing.

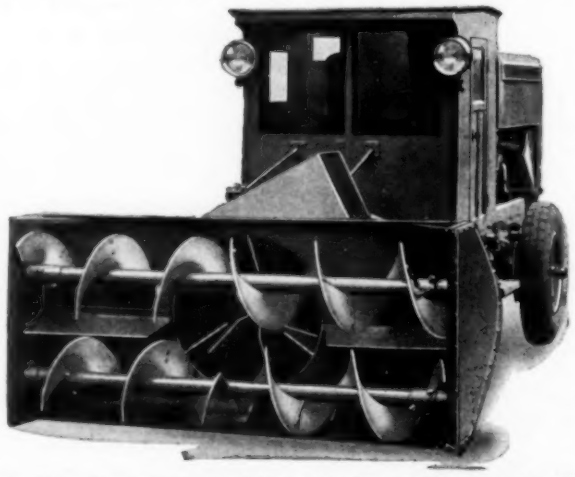
The machine, according to the manufacturers, has fully demonstrated that it will handle snow under any and all conditions, wet, dry, hard, soft or icy. The nozzle of the blower can be moved instantly from the cab, to right or left, and to any desired elevation. The front operating hood can also be raised and lowered instantly from the cab.

In a contest conducted several months ago for the purpose of choosing a name for this machine, the judges selected the name "Snogo," with the slogan, "The Alaskan Husky."

Fox Rotary Snow Loader.—The Fox Rotary Snow Broom Company, 2 Lafayette Street, New York City, manufacturers of a rotary snow broom widely used in municipal and railroad work, have perfected a rotary machine that will take snow or snow-ice from the street and load it into trucks for disposal at the rate of 100 cubic yards a minute, at a plowing rate of ½ to 15 miles per hour. This machine is mounted on a 3½ ton motor truck chassis powered by Buda 6-cylinder 90 h.p. motor and equipped with a Brown-Lipe 7 speed transmission. This machine cuts the snow by means of a number of toothed paddles that then convey the material to an esculator that lifts the snow and dumps it to the rear or to either side into truck or wagon. The vertical clearance of the machine with esculator lowered for transportation is 9 ft. 6 in., while with the machine in operating position the bottom of the chute is at the same distance from the ground. The chute is automatically raised or lowered from the operator's seat. The machine cuts a swath of 84 in.

Barber-Greene Snow Loader in Boston.—Joseph J. Comfrey, paving department, city of Boston, Mass., describing the use of Barber-Greene Snow Loaders by that city, reported as follows:

"This is the second season we have had our Barber-Greene loader. It was



Front View of the New Snow Remover Made by the Klauer Manufacturing Co., Showing the Cutting Augers That Deliver the Snow to the Blower

bought in time to help us out all through the winter season of 1923-24. We have used it during every big snow storm since it was bought, some of which required two or three days of continuous operation. It has been given very hard service but has never failed us at any time, in spite of severe weather or any other cause.

"Our force is ready to start clearing at any time of the day or night. As soon as two inches of snow have fallen the plows start right out on the main streets piling the snow into windrows. The Barber-Greene loader and the trucks come up behind the plows and pick up the windrows. From the main business district the snow is hauled about ½-mile and dumped. The loader ordinarily keeps about 9 trucks busy.

"The Barber-Greene is equipped with a side loader so that the trucks can be driven right alongside of the machine for loading. It is equipped with a large scoop which feeds the snow onto the conveyor belt. Being mounted on a full caterpillar type tractor, the machine moves ahead against considerable resistance at speeds ranging from 30 to 130 ft. per minute.

Cost Reduced 56 Per Cent. — The trucks are fitted up with very high side boards so that they carry from 8 to 10 cubic yards of snow on each load. The loader is used with all grades of light and heavy snow and loads a truck in from 45 to 90 seconds. This is very fast loading which results in the most efficient use of the trucks possible.

The cost of snow removal has been reduced about 56 per cent through the use of the Barber-Greene loader, and is now very low. These costs are shown in detail in the accompanying tabulation.

Low Cost.—Even if conservatively spread over an average of only 18 days of use per year, the fixed costs amount to but $144.03 per day operated. Added to this the cost of gasoline, oil and the wages of four men, gives a total daily cost of operation for the loader of $173.93 for 10 hours.

The loader usually runs from 6 o'clock in the evening to 6 in the morning, with 2 hours for changes in shifts. The 9 trucks for this work cost the city about $252.00. Adding this truck cost to the cost of operation of the Barber-Greene loader and the cost of 2 additional men to move automobiles out of the way and to help in other work, gives a total daily cost for snow removal of $439.13. The average cost per cu. yd. is 18 cents. Previously the loading of the snow from the windrows into the trucks was all done by hand. This was much slower, held up each truck considerably while being loaded, made it necessary to employ a large number of men and trucks, made the cost of snow removal much greater, and did not get the work done nearly as satisfactorily. With this method it required at least 10 minutes to load a truck, using a minimum of at least 10 men.

Save $10,276.66 a Year.—Even then the trucks could be loaded with only 5 to 6 cubic yards of snow. Larger loads were impractical because of the difficulty of throwing the snow over very high side boards. The time required for loading, cut down the number of trips made by the trucks to 2 or less per hour. We used a total of at least 20 trucks then and it was necessary to be loading at least 9 trucks at a time, in order to keep them moving.

The Haiss Snow Loader Used in a Number of Cities

This required a gang of about 90 men shoveling.

The total cost of this work including labor and trucks, as shown in Table I, amounted to about $1,010 per day for 10 hours work. That was 2½ times the present cost of doing the work with the Barber-Greene Loader. The actual saving in cost which has been obtained, is $570.87 per 10-hour run. The average saving per year on the conservative basis of eighteen 10-hour days of use amounts to $10,275.66.

This saving repays the entire cost of the Barber-Greene loader in less than 14 days operation, and shows how little it has to be used to pay for itself in one season. During a real severe winter the loader will save enough to pay for itself a good many times over so that we would not think of being without it from a cost standpoint alone.

Flexibility Results in Satisfaction.—In addition to these savings the work is handled much more satisfactorily with the Barber-Greene loader than by the old method. It used to be difficult to get enough men and trucks on short notice to work after midnight in order to get the work done at all, whereas the loader is ready to go at any time in any temperatures and for as long as necessary and it is easy to get the few men and comparatively few trucks required to do the work. Now we can be sure of getting the snow removed and there has not been any storm yet which has not been easily handled with our loader. The loader picks up the snow and leaves the street just as clean as hand shoveling does. We have no trouble in using the loader on any of Boston's narrow and crooked streets. When the street is too narrow for side loading, the side loader is disconnected and the trucks loaded by backing along behind the loader. The loader is easy to operate and can be used in these streets very satisfactorily.

During the first winter the loader was used about 20 times and was operated a total of about 30 days. Except for a few very minor replacements we have not had to do a thing in the way of repairs. The Barber-Greene snow loader has thus far given splendid satisfaction. We have received very quick and satisfactory service whenever desired and have found the Barber-Greene Company a good one to deal with.

Haiss Snow Loader.—The Haiss Snow Loader has high capacity in light snow, the power and creeper mounting to travel anywhere, the weight, strength, power and cutting action to handle frozen snow, and the positive feeding device and clean-up scraper to do away with pick and shovel on any snow work. With a 4 ton crane the snow boom can be removed and a standard bucket loader boom substituted, making it a standard Haiss Creeper Loader for handling broken stone, sand, gravel, cinders and easy excavation.

The Haiss Snow Loader has the Standard Haiss Creeper Chassis on which is mounted a special conveyor element instead of the standard bucket elevator. This snow conveyor is of the flight type with a steel plate trough 33 in. wide and flights 11 in. high, 24 in. apart, carried by two regular loader elevator chains. The tail shaft carries the standard feeding propellers which are followed by a standard clean-up scraper. The crowding speed has been increased to 8 ft. per minute to keep up with the capacity of the loader which is rated at 5 cu. yd. per minute. There are no other changes from the standard. The elevator is adjusted by the regular worm and jack knife action and standard engine, creeper unit and transmission are used. The creeper links have holes cored for grousers to be used when the streets are slippery. The flights are ¼-in. steel plate, bent to give a cutting action at the tail shaft, and for stiffness, and are equipped with teeth. The Snow Loader is converted into a standard creeper loader for stone, gravel, sand, etc., by substituting a standard bucket elevator boom for the snow boom. An adjustment of the ele-

Table I—City of Boston Tabulation of Cost and Savings

Cost of Operation—Barber-Greene Snow Loader with Trailer for Side Discharge

Depreciation—$7,800.00÷4 years	$1,950.00
*Average interest at 6%—$\frac{5}{4}\times\frac{\$7,800.00\times.06}{2}$	292.50
Maintenance and repair allowance	350.00
Total annual fixed charges	$2,592.50
Average fixed charges per day operated—$2,592.50÷18 days	$ 144.03
Gasoline and oil, average	3.50
Labor—4 men×$6.60	26.40
Total cost of operation per day (12 hours)	$ 173.93

Total Cost of Snow Removal Using Barber-Greene Loader

Length of haul, average	½ mile
Number of trucks used	9
Trips per hour per truck	3
Average loads	8 to 10 cu. yds.
Time required for loading	45 to 90 seconds
Daily cost of Barber-Green loader	$ 173.93
Cost of trucks—9 trucks×($23.00÷$5.00 overtime)	252.00
Helpers—2 men×$6.60	13.20
Total cost of snow removal	$ 439.13
Cost per cubic yard of snow removed, average $439.13÷2,430	$ .18

*Allowed for interest earned by depreciation reserve.

Total Cost of Snow Removal Without Barber-Greene Loader

Method of hand loading for 10 hours continuous work on streets near the Boston Commons

Length of haul, average	½ mile
Number of trucks used	20
Trips per hour per truck	2
Average load carried by trucks	5 to 6 cu. yds.
Time required to load a truck, average	10 min.
Total number of men in the gang—9×10	90
Labor cost—90 men×10 hrs.×$.50	$ 450.00
Total cost of trucks—20×($23.00÷$5.00 overtime)	$ 560.00
Total cost of snow removal	$1,010.00
Average cost per cubic yard of snow removed, $1,010.00÷2,400	$ .42

Savings Effected Through Use of Barber-Greene Loader

Total cost of snow removed without Barber-Greene loader	$1,010.00
Total cost of snow removed using Barber-Greene loader	439.13
Saving per day	$ 570.87
Average saving per year for 18 days of use—18×$570.87	$10,275.66

This saving repays cost of loader in less than 14 days of use or 1.3 times during the average season.

vator guides on the chassis is the only thing that is required.

Side Dump Truck.—On snow removal work where snow must be loaded into trucks and hauled to a dumping ground, such as in municipal work or in cleaning out cuts on a narrow highway, a side dump truck might well be used to advantage. With such equipment, the time lost by turning and backing the truck prior to dumping the load could be entirely eliminated and the truck could be kept doing productive work, hauling loads, a greater proportion of the time. Such a truck body, of a number of sizes, is now manufactured by the Differential Steel Car Company, Findlay, Ohio. This new equipment, known as the Differential 3-way Dump Body, dumps to either side or to the rear at the will of the driver. Selection of dumping direction is done by means of a handy lever at the driver's seat. This lever, set to one of the three notches that control the dumping direction, locks the side to which the truck is to dump and unlaches the other side and rear. For rear dumping, both sides are unlatched and the rear is latched—all automatically by means of setting the lever to the desired notch. The hoist itself is of the telescoping screw type with ball and socket joints at top and bottom. Power is taken from the reversing power takeoff of the power plant of the truck by means of a propellor shaft and bevel gears. Control is simple and automatic. The ball and socket connections of the screw hoist make installation simple and permit the body to weave and move about without transmitting stresses to the hoist. The body is equipped with hinged side gates that automatically open outward and downward during the hoisting operation, forming a continuation of the floor without projections to slow up discharge of the load, and designed to carry the load clear of the wheels. The tail gate is so designed that it can pivot at the top to act as a spreader gate, or at the bottom as do the side gates. This truck should prove equally useful in the summer work, for when hauling stone or gravel the load can be discharged to either side of the road or down the center, or spread, without any maneuvering of the truck except for slowing down or coming to a stop. It should prove of value when dumping over an embankment, since the danger attendent upon backing to the edge of the fill are avoided.

Crushed Stone Production in 1926.—According to a compilation of reports from producers made by the U. S. Bureau of Mines the production of crushed stone in 1926 amounted to 82,515,160 short tones, valued at $87,872,014 in 1926, an increase over 1925 of 9 per cent in quantity. Crushed stone for concrete and road work (66,892,530 tons, valued at $75,049,930) increased 6 per cent in quantity, and crushed stone reported as used for railroad ballast (15,623,030 tones, valued at $12,822,084) increased 22 per cent.

Motor-Truck Impact Investigations

One of the recent highway research projects initiated by the U. S. Bureau of Public Roads is an investigation of motor-truck impact.

The investigations of motor-truck impact as influenced by road type and as influenced by wheel type constitute two separate but related investigations. The first of these is for the purpose of determining the cushioning properties of the various road types under controlled conditions of motor-truck impact. A number of road types such as plain concrete, sheet asphalt on concrete base, bituminous concrete on concrete base, and penetration macadam will be selected in the vicinity of Washington, and on these sections motor-truck impacts will be produced identical as to conditions of drop, load, and tire equipment. Comparison between pavement types will then be made on the basis of the magnitude of the impact developed on each under exactly comparable test conditions. Any cushioning properties inherent in the pavement types should tend to decrease the magnitude of the impact.

Two methods are possible for producing the impact forces. The impact machine which has been in use for some years on the slab impact tests can be made portable. This machine is designed to give a wide range of impact blows, and measurement would be made of the height of drop of a wheel representing various conditions of truck load and equipment and the impact reaction. It is also planned to have a truck used in other impact investigations pass over artificial obstructions and to compute the impact forces produced from the record of an accelerometer attached to the truck. The first tests will probably be made under conditions representing a worn tire and heavy truck; and if the differences in impact reactions warrant, the program will be amplified to include other conditions. The tests on bituminous types will include as wide a range as possible of temperature conditions.

The investigation to determine the relative cushioning effect of various types of motor-truck wheels will be similar to but less extensive than the recently completed tests with various tire equipments. Wheels to be tested will include steel disk, wood spoke, and cushion types.

A 2-ton truck will be loaded so as to have 2,500 pounds on each rear wheel and later 5,000 pounds on each rear wheel, and equipped with dual pneumatic, dual new cushion, and dual worn solid tires, and will be operated at various speeds over different types of pavement and artificial obstacles. Impact forces will be measured by the coil-spring accelerometer and comparisons made where all conditions are constant except the type of wheel.